EDGE User Guide

Version 2.1

Last Modified 2018.11.27

Corresponds to EDGE Software Version 2.1

Includes All Building Types

International Finance Corporation

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CHANGE LOG

V2.1

This is the first version of the Combined User Guide for all EDGE building types. The organization of the User Guide has been altered to accommodate some new information.

This User Guide contains the complete list of efficiency measures available in EDGE. In the Energy and Water categories, the measures are listed in a new order to accommodate all building types. No change has been made to the order of the Materials measures which are common to all building types.

Previous versions of the User Guide contained an Appendix with details of Materials. This Appendix has been removed from this version; and is now located in a separate document called the 'EDGE Materials Reference Guide'.

The last Appendix contains a list of recent policy changes in EDGE; it will be updated periodically to reflect any new policy changes going forward. This Appendix replaces the User Guide Supplement.

LOCATE MEASURE DESCRIPTIONS

This Combined User Guide contains all the EDGE measures for all building types from the EDGE software; the measure number from the EDGE software is included under each measure name. The search function can be used to locate the description of any measure from the EDGE software in this User Guide by searching for its respective measure number (e.g. HTE11). Or, the measures can be located using the look-up tables on the following pages.

How to use the look-up tables:

1. Note the Measure Number in the EDGE App for the specific building type that you wish to review.
2. Go to the 'Look-Up Tables' on the following pages and find that Measure Number and the corresponding user guide Measure Code next to it.
3. Locate the user guide Measure Code from the Table of Contents.

For example, to view the measure description for HTE11 for Hospitality (previously referred to as Hotels), see Measure E13 in this User Guide. This example is highlighted in the look-up table on the next page.

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HOMES		HOSPITALITY		RETAIL		OFFICES		HOSPITALS		EDUCATION	
EDGE App Measure#	*User Guide Location*	*App Measure#*	*User Guide Location*	*EDGE App Measure#*	*User Guide Location*	*EDGE App Measure#*	*User Guide Location*	*EDGE App Measure#*	*User Guide Location*	*EDGE App Measure#*	*User Guide Location*
ENERGY EFFICIENCY MEASURES											
HME01	E01	HTE01	E01	RTE01	E01	OFE01	E01	HSE01	E01	EDE01	E01
HME02	E03	HTE02	E02	RTE02	E03	OFE02	E03	HSE02	E03	EDE02	E03
HME03	E04	HTE03	E05	RTE03	E04	OFE03	E04	HSE03	E04	EDE03	E04
HME04	E02	HTE04	E06	RTE04	E05	OFE04	E02	HSE04	E02	EDE04	E02
HME05	E05	HTE05	E07	RTE05	E06	OFE05	E05	HSE05	E05	EDE05	E05
HME06	E06	HTE06	E08	RTE06	E09	OFE06	E06	HSE06	E06	EDE06	E06
HME07	E07	HTE07	E09	RTE07	E16	OFE07	E07	HSE07	E07	EDE07	E07
HME08	E08	HTE08	E09	RTE08	E14	OFE08	E08	HSE08	E08	EDE08	E09
HME09	E09	HTE09	E14	RTE09	E12	OFE09	E09	HSE09	E09	EDE09	E09
HME10	E10	HTE10	E12	RTE10	E13	OFE10	E10	HSE10	E09	EDE10	E10
HME11	E11	HTE11	E13	RTE11	E22	OFE11	E14	HSE11	E09	EDE11	E14
HME12	E25	HTE12	E22	RTE12	E15	OFE12	E12	HSE12	E16	EDE12	E12
HME13	E27	HTE13	E15	RTE13	E26	OFE13	E13	HSE13	E14	EDE13	E13
HME14	E28	HTE14	E26	RTE14	E19	OFE14	E22	HSE14	E12	EDE14	E22
HME15	E36	HTE15	E19	RTE15	E20	OFE15	E15	HSE15	E13	EDE15	E15
HME16	E32	HTE16	E21	RTE16	E21	OFE16	E23	HSE16	E22	EDE16	E26
HME17	E32	HTE17	E24	RTE17	E24	OFE17	E26	HSE17	E15	EDE17	E19
HME18	E33	HTE18	E25	RTE18	E17	OFE18	E19	HSE18	E26	EDE18	E20
HME19	E39	HTE19	E27	RTE19	E25	OFE19	E20	HSE19	E19	EDE19	E21
HME20	E40	HTE20	E35	RTE20	E27	OFE20	E21	HSE20	E20	EDE20	E24
HME21	E38	HTE21	E29	RTE21	E32	OFE21	E24	HSE21	E21	EDE21	E25
HME22	E41	HTE22	E30	RTE22	E32	OFE22	E25	HSE22	E24	EDE22	E27
HME23	E42	HTE23	E31	RTE23	E32	OFE23	E16	HSE23	E18	EDE23	E32
HME24	E43	HTE24	E28	RTE24	E33	OFE24	E32	HSE24	E25	EDE24	E32
		HTE25	E32	RTE25	E37	OFE25	E32	HSE25	E27	EDE25	E33
		HTE26	E32	RTE26	E39	OFE26	E33	HSE26	E29	EDE26	E33
		HTE27	E32	RTE27	E40	OFE27	E33	HSE27	E30	EDE27	E33
		HTE28	E33	RTE28	E34	OFE28	E33	HSE28	E31	EDE28	E33
		HTE29	E33	RTE29	E41	OFE29	E33	HSE29	E32	EDE29	E39
		HTE30	E39	RTE30	E42	OFE30	E40	HSE30	E32	EDE30	E40
		HTE31	E40	RTE31	E43	OFE31	E41	HSE31	E32	EDE31	E41
		HTE32	E41			OFE32	E42	HSE32	E33	EDE32	E42
		HTE33	E42			OFE33	E43	HSE33	E33	EDE33	E43
		HTE34	E43					HSE34	E33		
								HSE35	E39		
								HSE36	E40		
								HSE37	E41		
								HSE38	E42		
								HSE39	E43		

Table 2. Look-up table for Water Measures in EDGE App mapped to the Location in the User Guide

HOMES		HOSPITALITY		RETAIL		OFFICES		HOSPITALS		EDUCATION	
User Guide Location	*App Measure#*	*User Guide Location*	*EDGE App Measure#*	*User Guide Location*	*EDGE App Measure#*	*User Guide Location*	*App Measure#*	*User Guide Location*	*EDGE App Measure#*	*User Guide Location*	*EDGE App Measure#*
WATER EFFICIENCY MEASURES											
HMW01	W01	HTW01	W01	RTW01	W03	OFW01	W02	HSW01	W01	EDW01	W01
HMW02	W05	HTW02	W02	RTW02	W04	OFW02	W03	HSW02	W02	EDW02	W02
HMW03	W02	HTW03	W03	RTW03	W02	OFW03	W04	HSW03	W03	EDW03	W03
HMW04	W03	HTW04	W08	RTW04	W05	OFW04	W05	HSW04	W04	EDW04	W04
HMW05	W03	HTW05	W04	RTW05	W06	OFW05	W10	HSW05	W06	EDW05	W05
HMW06	W12	HTW06	W03	RTW06	W07	OFW06	W12	HSW06	W07	EDW06	W10
HMW07	W13	HTW07	W02	RTW07	W11	OFW07	W13	HSW07	W05	EDW07	W12
HMW08	W14	HTW08	W06	RTW08	W10	OFW08	W14	HSW08	W09	EDW08	W11
		HTW09	W07	RTW09	W12			HSW09	W11	EDW09	W09
		HTW10	W05	RTW10	W13			HSW10	W10	EDW10	W13
		HTW11	W11	RTW11	W14			HSW11	W12	EDW11	W14
		HTW12	W15					HSW12	W13		
		HTW13	W10					HSW13	W14		
		HTW14	W12								
		HTW15	W13								
		HTW16	W14								

Table 3. Look-up table for Materials Measures in EDGE App mapped to the Location in the User Guide

HOMES		HOSPITALITY		RETAIL		OFFICES		HOSPITALS		EDUCATION	
User Guide Location	*App Measure#*	*User Guide Location*	*EDGE App Measure#*	*User Guide Location*	*EDGE App Measure#*	*User Guide Location*	*App Measure#*	*User Guide Location*	*EDGE App Measure#*	*User Guide Location*	
HMM01	M01	HTM01	M01	RTM01	M01	OFM01	M01	HSM01	M01	EDM01	M01
HMM02	M02	HTM02	M02	RTM02	M02	OFM02	M02	HSM02	M02	EDM02	M02
HMM03	M03	HTM03	M03	RTM03	M03	OFM03	M03	HSM03	M03	EDM03	M03
HMM04	M04	HTM04	M04	RTM04	M04	OFM04	M04	HSM04	M04	EDM04	M04
HMM05	M05	HTM05	M05	RTM05	M05	OFM05	M05	HSM05	M05	EDM05	M05
HMM06	M06	HTM06	M06	RTM06	M06	OFM06	M06	HSM06	M06	EDM06	M06
HMM07	M07	HTM07	M07	RTM07	M07	OFM07	M07	HSM07	M07	EDM07	M07
HMM08	M08	HTM08	M08	RTM08	M08	OFM08	M08	HSM08	M08	EDM08	M08

ACRONYMS

AHU	Air Handling Unit
ARI	Air-conditioning and Refrigeration Institute
ASHRAE	American Society of Heating Refrigerating and Air-conditioning Engineers
Btu	British thermal unit
cfm	Cubic feet per minute (ft^3/min)
COP	Coefficient of Performance
EDGE	Excellence in Design for Greater Efficiencies
HVAC	Heating, Ventilation and Air-conditioning
kW	Kilowatt
kWh	Kilowatt-hour
ppm	Parts per million
SC	Shading Coefficient
SHGC	Solar Heat Gain Coefficient
sqm	Square Meter
STP	Sewage Treatment Plant
TR	Tonnage of Refrigeration
VLT	Visible Light Transmission
VAV	Variable Air Volume
VFD	Variable Frequency Drive
VSD	Variable Speed Drive
W	Watt
Wh	Watt-hour
WFR	Window-to-Floor Ratio
WWR	Window-to-Wall Ratio

INTRODUCTION

About EDGE ("Excellence in Design for Greater Efficiencies")

EDGE is a green buildings platform that includes a green building standard, a software application, and a certification program for more than 140 countries. The platform is intended for anyone who is interested in the design of a green building, whether an architect, engineer, developer or building owner.

EDGE empowers the discovery of technical solutions at the early design stage to reduce operational expenses and environmental impact. Based on the user's information inputs and selection of green measures, EDGE reveals projected operational savings and reduced carbon emissions. This overall picture of performance helps to articulate a compelling business case for building green.

The suite of EDGE building types includes Homes, Hospitality, Retail, Offices, Hospitals, and Education buildings. EDGE can be used to certify buildings at any stage of their life cycle; this includes concept, design, new construction, existing buildings, and renovations.

EDGE is an innovation of IFC, a member of the World Bank Group.

A Global Green Standard

To achieve the EDGE standard, a building must demonstrate a 20% reduction in projected operational energy consumption, water use and embodied energy[1] in materials as compared to typical local practices. EDGE defines a global standard while contextualizing the base case to the building functions and its location.

Only a handful of measures are required for better building performance that result in lower utility costs, extended equipment service life, and less pressure on natural resources.

The EDGE Perspective

Rather than relying on complex simulation software and processes to predict resource use, EDGE has an easy-to-use interface that runs on a powerful building physics engine with region-specific data. Through user inputs, the data can be further refined to create a nuanced set of calculations that have greater accuracy when predicting future building performance. EDGE focuses intently on resource efficiency and climate change mitigation, recognizing that too wide of a focus leads to disparate results.

The intent of EDGE is to democratize the green buildings market, which was previously reserved for higher-end buildings standing in relative isolation in primarily industrialized nations. Government regulations in emerging economies rarely require resource-efficient building practices. EDGE aims to create a new path for green growth by proving the financial case in a practical, action-oriented way that emphasizes a quantitative approach. This approach closes the gap between non-existent or weakly-enforced green building regulations and expensive international standards. It realizes the potential to lower utility costs while reducing GHG emissions.

[1] Embodied energy is the energy required to extract and manufacture the materials required to construct and maintain the building.

INTRODUCTION

EDGE Methodology

At the heart of EDGE is a performance calculation engine that harnesses a set of mathematical equations based on the principles of climatology, heat transfer and building physics. Upon receiving design inputs, the calculator charts a building's potential performance in the areas of energy, water and materials. As markets mature, the underlying data in the calculator will be further sharpened, ensuring EDGE becomes more granular and up-to-date.

Energy consumption is predicted using a quasi-steady state model (refer to the EDGE Methodology). The quasi-steady state calculation methodology is based on the European CEN standards and ISO 13790. A similar approach has been taken by energy efficiency building codes (e.g. COMcheck in the U.S., Simplified Building Energy Model [SBEM] and SAP in the UK) and Energy Performance Certificates (EPCs in the EU) to find a quick and cost-effective way to benchmark buildings and to quantify carbon emission reductions. In the future, accredited dynamic simulation models will also be an acceptable means of demonstrating compliance with the EDGE standard.

To determine the base case parameters for efficiency in each of the required areas, EDGE relies on information on typical building practices and national building performance codes, where they exist. For example, if an energy efficiency code (EEC) is enforced in a certain country, such as China or South Africa, then it is used to support the base case calculation. Typical efficiencies for heating, ventilation and air conditioning systems are based on the ASHRAE 90.1-2007 standard without amendments.

This quasi-steady-state model considers thermal mass within the calculation, using the method detailed in ISO 13790:2008(E), Section 12.3.1.1, in which the heat capacity of the building (J/ºK) is calculated by summing the heat capacities of all the building elements facing directly into the interior of the building. However, this calculation is not a detailed thermal mass calculation (as might be possible using hourly simulation software).

Rather than suggesting a perfect or prescribed scenario, EDGE provides users with a set of best-practice options to explore to identify an optimum design solution. In this way, the user determines which bundle of technical measures is the best choice for their building to reach required efficiency levels.

The purpose of EDGE is to produce consistent and reliable evaluations of resource demand for building certification purposes. While EDGE assists the design process, it is first and foremost a model for directional financial comparisons. It should not be used for making decisions that require a finer level of detail. If the performance of a particular feature is critical to the project, then using an appropriate modelling tool would be prudent. For example, EDGE should not be used for system sizing, or precise payback calculations for financial decision-making.

EDGE uses the best available information on global or local averages as default values. The EDGE database is updated on an ongoing basis as new and better information becomes available. To share updates with the EDGE Team, such as local rates for energy and water, please send relevant documentation to edge@ifc.org.

EDGE Certification

EDGE certification is awarded if the required minimum efficiencies are achieved. A simple pass/fail system indicates whether the building project has demonstrated the minimum 20% savings in operational energy, water and embodied energy in materials compared to the base case model. Actual percentage savings for each project can be seen on the EDGE certificate as well as in project case studies on the EDGE website.

INTRODUCTION

Requirements for EDGE compliance, at both the design and post-construction phases, are specified for each measure in this guide, and include such deliverables as design drawings, manufacturers' data sheets, calculations, proof of delivery and photographs. A design review is required for preliminary certification and a site audit is required for the final EDGE certification, with both conducted by an accredited EDGE Auditor. Certification is awarded by a licensed EDGE certification provider. EDGE certification makes a statement of corporate excellence and environmental responsibility.

EDGE Software (Version 2) is optimized for the following:

- Browser (the following versions or higher): IE10, Firefox 30, Chrome 35 or Safari 5.1
- Operating System: Windows 7 or higher, or Mac OS
- Screen Resolution: Viewed best at 1680 X 1050 pixels
- Limited functionality is available on iPhones, Androids, and tablets

An Innovation of IFC

EDGE is an innovation of IFC, a member of the World Bank Group.

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EDGE CERTIFICATION GUIDANCE

Project Team/EDGE Experts

The project team or EDGE Experts demonstrate that the specifications for individual measures meet the minimum performance required for the improved case by providing the following:

- A brief explanation of the relevant system or product specified/installed.
- Calculations that have been used to assess and demonstrate compliance.
- Manufacturer's data sheets, with the information required to demonstrate compliance highlighted.
- Proof that the specified system or product has been installed.

EDGE Auditors

The EDGE auditor verifies that the design/construction team has interpreted the EDGE requirements correctly and that all compliance requirements have been fulfilled. The supporting evidence provided is reviewed to ensure it matches the data used in the assessment. Auditors must verify 100% of the floor area for a unique design for any building type. In the case of repetition in design, an auditor must verify the following at a minimum:

- Homes: (square root of the number of units) +1 for each type
- Hospitality or Health: (square root of the number of rooms) +1 for each type
- Retail, Offices or Education: 40% of similar areas for a project
- Multiple buildings of same type: (square root of the number of buildings) +1 for each type

Photographs used as evidence must be taken by the auditor during the site visit and include a date stamp.

EDGE Certifiers

The certification process involves auditing of the project documentation submitted by the project team, followed by the award of the certificate. Designated EDGE certifiers oversee the auditors and issue the EDGE certificates. Certification is done through the EDGE software online. The project team must apply for certification online through the EDGE software application. To begin, the project administrator or their consultant EDGE Expert may 'Express Interest' to request a quote from local auditor(s) and the certification provider via the EDGE buildings website. Or, a project may choose to 'Register' in the EDGE App. More information on the certification steps is available on the 'Certify' page at www.edgebuildings.com.

EDGE Assessment and Certification Definitions

- A **building** is defined as a conditioned (heated or cooled) or naturally ventilated structure with at least one full time equivalent occupant, and a minimum building area of 200m².
- A **single home** is a detached single-family home. There is no minimum area requirement.

- A **single building** is a physically separate structure. If two buildings are connected by a conditioned space, then they can be considered as a single building.

- Area limits for **mixed-use buildings:** If a building has more than one use and the secondary use occupies less than 10% of the floor area up to a maximum of 1,000m^2, the entire building can be certified under the primary use of the building. If the area of secondary use is more than 10% of the floor area or more than 1,000m^2, then that portion must be certified separately. For example, if a 10,000m^2 residential building has a retail portion of 1,200m^2 located within the ground floor, the building areas must be certified separately under the Homes and Retail typologies.

- **Multiple buildings:** When one project (such as a housing development) with a single owner consists of several buildings, buildings of less than 10% of the floor area of the project up to a maximum of 1,000m^2 with the same use may be clustered together as a single building. Buildings larger than 10% of the project floor area or more than 1,000m^2 must be considered as separate buildings. In **residential projects**, however, each individual unit would receive an EDGE certificate, not the overall building. When multiple types of units are present, each unit type in the project is assessed separately.

- **Project:** A Project is defined as the whole building or development submitted for EDGE certification with the same certifier and owner. For example, a Project may be a residential building with two towers, a mixed-use building with offices and retail space, or multiple buildings with the same specifications in a city or country. The information in the Project section in EDGE is the top-level information that applies to the whole project.

- **Subproject:** A Subproject is each portion of the Project modeled individually in EDGE. The information contained in the Subproject section applies only to the portion being modeled in that file. For example, a Subproject may be Unit Type 1 in a residential building, the retail space in a mixed-use tower, or an individual location for a chain of stores.

Grouping Logic for Residential Units (the 10% rule)

The 10% rule governs which residential units can be grouped together and modeled as a single unit type in EDGE.

<u>RULE: For any representative residential unit in EDGE, the actual area of the represented unit must be within 10% of the modeled area (± 10%). If the area of a unit differs from the average by more than 10%, it must be modeled separately.</u>

<u>Example 1</u>: Half the units in a project are Unit Type A (85 m^2) and the other half are Unit Type B (95 m^2). The average area of these two is 90 m^2/unit. The areas of Unit Types A and B are within 10% of 90 m^2, so Unit Types A and B can be modeled together in EDGE as, say, Unit Type 1 with an area of 90 m^2/unit.

Any number of similar units within a 10% area range of the average can be modeled together. The admissible area range for the units represented by Unit Type 1 in Example 1 is 90 m^2 ±10% = 81 m^2 to 99 m^2. This is illustrated in Figure 1 below. Any admissible units for Type 1 must be 81 m2 <Area.

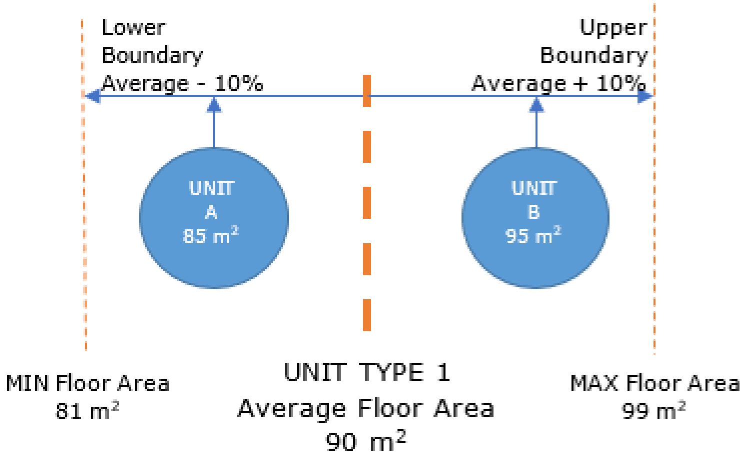


Figure 1. The admissible range of areas that can be represented by a single unit type in an EDGE residential model

Note 1. Units with areas outside the admissible range must be modeled separately.

Example 2: In Example 1 above, a unit with 80 m^2 area, or a unit with 100 m^2 area cannot be grouped in with Unit Type 1.

a. For individual unit area values into the decimals, a user should round up or down to the nearest single digit after the decimal.
Example 3: An area of 99.03 m^2 would round to 99.0 m^2, and therefore qualify in Example 1 above. But a unit with an area of 99.05 m^2 would round to 99.1 m^2 and would not qualify to be grouped with Unit Type 1 in Example 1.

b. The average values of unit areas must be kept to the second decimal place, to avoid unintended variation from the average.
Example 4: If half the units are 74.3 m^2 and the other half are 88.6 m^2, the average unit area will be 81.45 m^2. The permissible range of actual areas that can be represented by this average unit type is 90%x81.45 to 110%x81.45 = 73.3 m^2 to 89.6 m^2

Note 2. For units with unequal number of units, take the count-weighted average (not the simple average) of the area. This will result in correct total calculations of the GIA for the entire project.

Example 4. If there are 20 units of Unit Type A (80 m^2) and 30 units of Unit Type B (90 m^2), the count-weighted average is (20x80+30x90)/(20+30) = 86 m^2/unit (unlike Example 1 where it is 85 m^2).

Note 3. The rule only applies to similar units, that is, to units with the same number of bedrooms and high-level characteristics such as single story or duplex. Units of different types, such as 1-bedroom and 2-bedroom units, must be modeled separately.

a. EXCEPTION: If a unit type consists of 5 units or less and the total area of these units represents less than 10% of the project GIA, that unit type does not need to be modeled separately. It can instead be grouped with the most similar unit type.
Example 5: A building has 300 units of which 297 units are 2-bedroom units of assorted sizes, and only 3 units are one-bedroom units. In this case, the one-bedroom units may be grouped with the most similar 2-bedroom units.

Steps to Calculate and Test the Average Unit Area

Step 1 Calculate the weighted average.

Example 6. A project has 40 units of 3 different types as shown in the table below.

	Unit Count (n)	Unit Area (A) (m^2)
Unit A	10	86
Unit B	20	92
Unit C	10	100

The weighted average area per unit is:

$$\frac{n1A1 + n2A2 + n3A3}{n1 + n2 + n3}$$

or

(10x86+20x92+10x100)/(10+20+10) = 92.5 m^2/unit

Step 2 Calculate the acceptable range to determine whether the units can be grouped together.

In Example 6 above, the acceptable range can be determined as follows:

Minus 10% from the average value of 92.5 m^2 equals 90% x 92.5 = 83.3 m^2

Plus 10% to the average value of 92.5 m^2 equals 110% x 92.5 = 101.8 m^2

83.3 ≤ 86, 92, and 100 ≤ 101.8 is TRUE

Conclusion: Type A, Type B and Type C units in Example 6 are larger than 83.3 m^2 and smaller than 101.8 m^2. Therefore, they are within the acceptable range and can be grouped as one Unit type in EDGE.

Example 7. Type A units are 10 units of 80 m^2, and Type B are 10 units of 100 m^2

Average = (10x80+10x100)/(10+10) = 90 m^2

Acceptable range of unit areas:

Minus 10% from 90 m^2 equals 90% x 90 = 81 m^2

Plus 10% of 90 m^2 equals 110% x 90 = 99 m^2

81 ≤ 80 and 100 ≤ 99 is FALSE

Conclusion: The areas of Type A and Type B units are outside the acceptable range and therefore the units cannot be grouped together in EDGE.

Note: The related input for the 'External Wall Length /Unit' has a significant impact on results and must be represented correctly. It must be calculated by taking a weighted average of the exterior wall lengths for the units being modeled together.

Core and Shell Projects

Core and Shell projects are projects where the owner is responsible for the building exterior ("shell") and the core facilities ("core"), but the interior areas are constructed by the tenants ("fit out"). For Core and Shell projects, measures such as interior lighting for which the tenants are responsible can be claimed in EDGE only if a "tenant fit-out guide" is included in the lease agreement and signed between the tenants and owners. This tenant fit-out guide must define the requirements to be fulfilled by the tenants for each measure, and be included in the EDGE submission. If all tenants have not signed a lease at the time of EDGE certification, the building owner must show EDGE compliance by providing the template of the lease agreement accompanied by a signed letter stating that the tenant fit-out guide in the template lease agreement will be included in all tenant lease agreements signed for the building.

Partial Building Projects

A part of a building may apply for EDGE certification. For example, a store in a mall or an office in an office building can apply for EDGE certification. If that space is served by a central HVAC system, the EDGE application can document the specifications of the whole building HVAC systems. If the space is served by a stand-alone system, only that system must be documented. For the envelope, the wall lengths, materials, and WWR ratio should represent the actual space applying for certification. Only those exterior facades must be included that are directly in contact with/enclosing the part of the building applying for the EDGE certification. For example, if there is no exterior façade on the east side because the applicant part of the building is attached to the rest of the building on that side, then, the east façade length must be marked as 0.01 m. The same logic applies all the way around. It is possible to have a portion of a building with No exterior walls apply for EDGE, in which case All exterior facades will be marked as 0.01. This will ensure that the heat transfer and therefore, energy performance of the applicant building portion is calculated correctly.

Social Housing Projects

Social housing projects are at times provided without finished floors or bathrooms fittings in second bathrooms. For such projects, EDGE makes the following exceptions: (1) Unfinished floor areas can use the EDGE default flooring (ceramic tile), and (2) Bathrooms without fixtures can be ignored for Water measures. However, the bathrooms that do have fittings must have low-flow fixtures to claim the corresponding EDGE measures, as is normally the case. In addition, EDGE encourages developers to provide literature (such as product brochures) on low-flow fittings to prospective apartment buyers through the sales office.

Special Ruling Request (SRR)

A Special Ruling Request (SRR) is a mechanism for project development teams to request a Special Ruling from the Certifier on the eligibility of a method or procedure not outlined in the EDGE App to determine the compliance of a measure. This is applicable for situations where project development teams may want to (1) use an alternative method to comply with the intent of an EDGE Measure, or (2) use innovative strategies not included in the available EDGE Measures to reduce resource consumption in Energy, Water or Materials. The SRR form formally documents for audit purposes that a project development team has received special permission from IFC's EDGE team to use an out-of-the-norm procedure for claiming measure savings in the EDGE App. Actual compliance with the intent of the measure will still be subject to an audit.

Note that the SRR is a means of formal documentation for audit purposes only. In general, the EDGE User Guides and the Frequently Asked Questions available on the EDGE website serve as a starting point for questions related to the EDGE certification of projects. Further questions about EDGE project measures and certification can be directed to the respective EDGE Certification Provider selected for the project. In addition, the IFC EDGE team is available to help at edge@ifc.org.

When a project team has gone through the steps above and still needs documentation of approval for an atypical approach to its project, it can request a Special Ruling Request form from the certifier. In other words, the intent of the SRR is quite specific to special cases or alternate methods to achieve compliance with the intent of a measure -- that is, a method that is not covered in the User Guide, or an innovative measure not available in the EDGE measures list. For example, an SRR would be required for using an alternate tool outside EDGE to calculate the Average Annual Shading Factor (AASF) or to calculate the savings from an evaporative cooler or a VRF system with heat recovery. It is project specific. When the content is universally applicable, it will be added to the User Guide and not require an SRR for compliance anymore.

DESIGN PAGE GUIDANCE

The EDGE software opens in the Homes building type by default. Select the appropriate building type for your model from the top-level tabs.

Start from the Design section to build the base case for the building.

Saving a Project

Users may save their projects within the EDGE software to retrieve upon login. A user account is required to save a project file. Fields marked with an asterisk* are also required to save the project file.

EDGE can be accessed via handheld devices such as iPhones, Androids and tablets. Exercise caution when accessing saved projects via handheld devices as EDGE automatically saves changes to projects every three minutes.

If a user is not active on EDGE for 20 minutes, the system will log the user out and any unsaved changes will be lost.

To create multiple versions of a project with different combinations of measures, it is best to retain your inputs by downloading the data into separate PDFs and saving the documents on your computer (File > Download PDF). In this way, you maintain one project file for your building within EDGE.

Project Details

A Project is defined as the whole building or development submitted for EDGE certification with the same certifier and owner. For example, a Project may be a residential building with two towers, a mixed-use building with offices and retail space, or multiple buildings with the same specifications in a city or country. The information in the Project section in EDGE is the top-level information that applies to the whole project.

This section contains the top-level information about the Project, such as owner name and contact information, and is shared across a Project's Subprojects. Changes to the Project Details section are automatically reflected in Subproject files. This section must be completed to submit the project for audit and certification.

- Project Name* – The name of the development. Note that this is a required field that serves as the project identifier. To edit the project name after saving, go to File > Rename on the Design tab.

- Number of Distinct Buildings – The number of physical buildings that make up the whole project. This field is part of the project description that helps an auditor or reviewer understand the physical make-up of a project. This field helps account for the "number of buildings" certified by EDGE in a client's or auditor's portfolio. This value will be 1 for a single building, or for towers with a shared podium level. The value in this field is for information purposes only and is intended to help visualize the building during the quotation and certification process. The value does not get multiplied by the Gross Internal Area, unlike the "Subproject Multiplier for the Project" (see the description of that field below under Subproject Details).

- Number of EDGE Subprojects Associated – The total number of files associated with the Project. EDGE calculates this automatically based on the associations established by the user; therefore, this field is not editable by the user.

- Total Project Floor Area – The total square meters of internal area of the Project, including any indoor parking. The Total Project Floor area does not include areas outside the building(s) envelope, such as landscaped areas (gardens, patios, etc.) or outdoor parking areas. This is the sum of the Gross Internal Areas of all the associated Subprojects within the Project. EDGE calculates this automatically based on the areas and the *multipliers* (explained under "Subproject Multiplier for the Project") assigned to each Subproject by the user; therefore, this field is not editable by the user.
- Project Owner Name* – The name of the key contact from the company/organization that commissioned the EDGE assessment.
- Project Owner Email* – The email address of the key contact from the company/organization that commissioned the EDGE assessment.
- Project Owner Phone* – The phone number of the key contact from the company/organization that commissioned the EDGE assessment.
- Address Line 1 – Primary street address of the project.
- Address Line 2 – Any additional details for the street address, such as the building number.
- City – The city where the project is located.
- State/Province – The state or province where the project is located.
- Postal Code – The postal code where the project is located.
- Country – The country where the project is located.
- Project Number – This will be a system-assigned number, similar to the File Number currently in use.
- Upload project-level documents – This links to a space to upload whole project-level documents, for example, a site plan of the project.
- Download project audit documents – Clicking on this link downloads the entire set of project documents that have been uploaded thus far. Documents for individual measures are placed in their respective folders. This allows a project team member to access any project document from one central location. This link is also used by the EDGE Auditor for project documentation review.
- "Register" button – The Register button in the Project section in the Design tab now allows a whole project to be registered as one entity and triggers a quotation to be sent.
- "Associated Subprojects" – This link in the Project Details section expands to show all the Subprojects associated with that Project in addition to the Subproject currently open in the EDGE App.

Subproject Details

A Subproject is each portion of the Project modeled individually in EDGE. The information contained in the Subproject section applies only to the portion being modeled in that file. For example, a Subproject may be Unit Type 1 in a residential building, the retail space in a mixed-use tower, or an individual location for a chain of stores.

This section contains fields associated only with the portion of the Project being described in the current file.

- Subproject Name* – The portion of the project being modeled. For example, Residential tower, office, or warehouse. This is a required field.
- (Building) Name* – The name of the building being modeled. The field name varies by building type. For example, in Homes it is the 'House or Apartment Block Name' and in Hospitality, it is the 'Property Name'. This is a required field.
- Subproject Multiplier for the Project – This input represents the number of times the building portion modeled in a file is repeated in the Project. For example, consider that a residential development has forty (40) identical detached 2-bedroom homes (Home Type 1), and two identical towers with twenty five (25) similar-sized 3-bedroom apartments each (Home Type 2). The Subproject file for Home Type 1 will contain the information – such as physical characteristics including the average area and exterior wall lengths – of only one 2-bedroom home; the "Subproject Multiplier for the Project" in this case must have the value "40" to account for the total floor area in the project. Similarly, the Subproject file for Home Type 2 will contain the information – such as physical characteristics including the average area and exterior wall lengths – of only one tower which includes 25 3-bedroom units; the "Subproject Multiplier for the Project" in this case must have the value "2" to correctly account for the project's total floor area. These values are critical to correctly capture the "Total Project Area."
- Certification Stage* – The stage of certification of the project. Enter "Preliminary" for projects in the design stage of new construction or renovation. Enter "Post-Construction" for new construction or renovation projects that have completed construction and are ready for the final verification phase of certification. For existing buildings applying for certification, enter "Post-Construction" from the very beginning of the certification process, regardless of the length of time elapsed since construction. For example, an existing project built one month ago, or ten years ago, would both enter "Post-Construction". This is a required field.
- Do you intend to certify?* – Select Yes, No, or Not Sure, to indicate the intent regarding certification of the Subproject.
- Status – This information field displays the status of the project lifecycle. For example, self-review, registered etc.
- Auditor – This information field displays the Auditor assigned to the project.
- Certifier – This information field displays the Certification Provider for the project.

Subproject Address: This is the address that will go on the EDGE certificate. The Subproject Address may or may not be the same as the Project Address. For example, if a Project has Subprojects in several locations around a city, each Subproject may have its own address.

- Address Line 1* – Primary street address of the subproject.
- Address Line 2 – Any additional details for the street address, such as the building number.
- City* – The city where the subproject is located.
- State/Province – The state or province where the subproject is located.
- Postal Code – The postal code where the subproject is located if applicable.
- Country* – The country where the subproject is located.
- Subproject Type – The stage in the lifecycle of the building. "New Building" must be selected for new construction and "Existing Building" for existing buildings and renovations.
- Year of Construction – This field only applies to Existing buildings. Enter the year the project was completed, that is, the year the project received the occupancy permit. If the project was completed before the earliest year available in EDGE, select the earliest year available and add a note in the Project Narrative section.

Building Utility Data

This section only applies to Existing building projects. The intent of this section is to track the energy performance and water usage of the existing building that is applying for EDGE certification. The values can be taken from the most recent past year with full occupancy.

- Annual Measured Electricity Consumption – The recorded annual electricity usage of the subproject being modeled, expressed in kWh/year.
- Annual Measured Water Consumption – The recorded annual water usage of the subproject being modeled, expressed in m3/year.
- Annual Measured Natural Gas Consumption – The recorded annual natural gas usage of the subproject being modeled, expressed in m3/year.
- Annual Measured Diesel Consumption – The recorded annual diesel usage of the subproject being modeled, expressed in kL/year.
- Annual Measured LPG Consumption – The recorded annual usage of liquefied petroleum gas (LPG) of the subproject being modeled, expressed in kg/year.

DESIGN PAGE GUIDANCE

Location Data

- Country – The country in which the project is located. If the actual country of the project location is not in the EDGE drop-down list, select a country and city that is most similar in climate from the available options.

- City – The city in which the project is located. If the building is in a city which is not included in the EDGE drop-down list, select the city that is closest in terms of climate. If necessary, overwrite the defaults under Advanced Settings > Key Assumptions for the Base Case > "Monthly Average Outdoor Temperature (deg. C)", "Latitude (deg.)" and "Average Annual Rainfall (mm)"

Basic Parameters

These vary by the building type being modeled. They are described together with the Building Data section below.

Building Data and Area Details

Building Data fields capture the physical make-up of the buildings in terms of activities, floors and areas by space type. The fields depend on the building type and may be listed under the sections Basic Parameters or Building Data.

The Area Details section in the software indicates the area breakdown by activity type. The types of spaces available in a model also depend on the building type. The comprehensive list of space types is provided below in alphabetical order for each building type in EDGE. Descriptions are provided only when necessary.

EDGE assigns to each space type in a model a default value (in m²) as a percentage of the gross internal area based on the type and sub-type of building selected. If the actual area for any space type differs from the default value, it can be overwritten by providing a value in the "User Entry" field. Please note that zero (0) is not an acceptable value in EDGE. If a space type does not exist, use a minimal value such as 0.01m² to overwrite the default.

Homes

- Income Category – The income category of the target market for the project. The selected income category will determine the assumptions EDGE makes on usage patterns, equipment levels, and room sizes.

- Type of Unit –Type of dwelling, i.e. flats/apartments or house

- Average Unit Area (m²) – Average internal area of a residential unit including occupied spaces, utility, balcony, and service shaft attached to a unit. This does not include common areas or external walls, and partition walls between individual units.

- Bedrooms/Unit – Number of bedrooms in a unit.

- Floors – Number of floors for the entire area of building that is covered by the assessment. For projects being modeled in sections with multiple EDGE models, the Floors field must only show the number of

Floors that section represents. For example, if residential units are being modeled separately, the Floors field must show only the number of Floors for that unit. If a unit type appears on 10 floors, the value must be 10. If a unit is a duplex, 2 floors must be entered per unit. If the duplex unit appears on 3 floors, the number of floors must be 6.

- Units –Number of units within the building that are covered by the assessment. This will be the total number of units per typology being represented by that model. In the case of identical buildings that can use the same model, use the multiplier to represent the total units in the Project.
- Occupancy (People/Unit) – Average number of people that would typically reside in each dwelling. If this is unknown, use number of bedrooms + 1. For example, for a 3-bedroom unit, use 3+1 = 4.

Table 4: Area Details in Homes

Building Type	*Indoor Space Type*	*Description*
HOMES	Bedroom	A default value (m^2) is provided based on the selected income category. If the actual area differs from the default, then enter it here.
	Kitchen	A default value (m2) is provided based on the selected income category. If the actual area differs from the default, then enter it here.
	Living and Dining	A default value (m2) is provided based on the selected income category. If the actual area differs from the default, then enter it here.
	Bathroom	Bathrooms and toilets
	Utility, Balcony, Service Shaft	The Utility, Balcony, Service Shaft (m^2) field is equal to the remaining space required to total the Gross Internal Area (m^2). This value is automatically calculated and cannot be overwritten.
	Gross Internal Area	The Gross Internal Area (m^2) field is the sum of the room areas listed directly above, and must equal the Average Unit Area (m^2) that the user entered in the Building Data section. If the user's inputs total a greater amount, then a negative number will appear in the "Utility, Balcony, Service Shaft" which must be corrected by the user. The total area (m^2) must be measured from the inside of the external walls. Distances to interior walls are measured on center. This value impacts savings calculations.
	External Wall Length (m/Unit)	This length is provided by default assuming a ratio of 1.5:1 for the floor length to width. The value represents the average length of the exterior wall of all the similar units being represented in that model. This value has a significant impact on savings and must be calculated carefully and cross-checked.

	Roof Area/Unit (m^2)	The input for this value is the average roof area for all the units being modeled. For example, if a Subproject file represents 50 units, and only 5 of them have an exterior roof of 100 m^2 each, the Roof Area/Unit = (5x100)/50 = 10m^2. If a set of units includes only interior units with no exposed roof area, this value should be zero (input 0.01 m^2 in EDGE as it does not accept zero)
	Window-to-Floor Ratio	EDGE calculates a default value for the window to floor ratio. To change this percentage, HME01 in the Energy section must be selected and altered.
	Common area/Unit (m^2)	These are the shared spaces in buildings with apartments or multifamily units. For example, corridors, lobby, gymnasium and community rooms. This area is not part of the GIA of the unit type, but contributes to the total project area. The common area of the entire Project should be calculated, divided by the total units in the Project, and the same value input for each Subproject.

Hospitality

- Property Type – Specific type of property, that is hotel or resort or a serviced apartment, based on site configuration. Hotels assume shorter stays and business use, while Resorts assume longer stays and vacationer use. Serviced apartments are residential-style furnished apartments with included services such as maintenance, regular cleaning and laundry for the residents.
- Average Occupancy Rate – Annual average percentage of nights that the rooms or units within the property are occupied by guests.
- No. of Units – These fields only apply to Serviced Apartments. The number of units of each type based on number of bedrooms, or penthouse apartments.
- Select the type of amenities and services that the property provides (Irrigated area, laundry, banquet /conference, breakfast area only (no restaurant), health spa, swimming pool.)
- Star Rating of the Hotel – This field only applies to Hotels and Resorts. Industry standard star rating of the hotel or resort.
- Resort Type – Only applies to resorts which may be a single building or spread out over multiple buildings.
- Floors Above Ground – Total number of floors above the ground level.
- Floors Below Ground – Total number of floors below the ground level.
- Total Guest/Bed Rooms – Total number of guest rooms in the hotel or resort or the number of bedrooms in a Serviced Apartment.

Table 5: Area Details in Hospitality

Building Type	*Indoor Space Type*	*Description*
HOSPITALITY	Guest Rooms/Apartment Area	A default value (m^2) is provided based on the property type. If the actual area differs from the default, then it can be entered here.
	Corridors	As commonly understood
	Lobby	Area of the lobby of the property in Serviced Apartments
	Recreational Area	Area of the guest amenities such as retail area, gymnasium, and indoor pool in Serviced Apartments.
	Front of House	Area of lobby, restaurants, gymnasium and indoor pool etc. in Hotels and Resorts
	Conference/Banquet	This area only applies to Hotels and Resorts
	Back of House	Incudes all back of house functions such as kitchen, storage, and mechanical and electrical room.
	Gross Internal Area	Sum of the space areas listed directly above. It represents the total internal area of the property. The total area (m^2) of the building must be measured from the inside of the external walls. Distances to interior walls are measured on center. This value impacts savings calculations.

Retail

- Type of Retail – Specific type or category of retail. The available options are department store, shopping mall, supermarket, small food retail and non-food big box retail. In addition, light industry (such as a garment manufacturing unit) and warehouse (such as a storage facility) are included.
- Site Area (m^2) – Total boundary area of the site where the building will be constructed.
- Car Parking – Type of car parking provided: "None" when no car parking is provided; "Indoor car parking" when the primary car park is located inside the building; and "Outdoor car parking" when parking is located outdoors.
- Use – Number of shifts that the building is in use: 1 shift, 2 shifts or 3 shifts, with each shift being 8 hours/day, 6 days a week. This field only applies to Light Industry and Warehouses.
- Select the type of amenities and services that the retail building provides (landscaped area, supermarket, and/or food court). Note that a pantry should not be represented as a food court.
- Floors Above Ground – Total number of floors at and above the ground level. For buildings with a different number of floors in different areas, use the weighted average number of floors. For projects being modeled in sections with multiple EDGE models, the Floors field must only show the number of

Floors that section represents. For example, if residential units are being modeled separately, the Floors field must show only the number of Floors for that unit.

- Floors Below Ground – Total number of floors below the ground level. The same logic applies as for Floors Above Ground (see immediately above) for a different number of floors in different areas.
- Floor-to-Floor height – Total floor-to-floor height, including the height of the slab. In the case of floors with false ceilings, this height is floor-to-ceiling. Use a weighted average for buildings with varying floor heights.
- Gross Internal Area Including Car Parking (m^2) – Total internal area of all the spaces of the retail store. This includes the sales area, storage area, corridors, offices, food court, bathrooms, mechanical and electrical rooms and indoor car parking. Calculate and enter the total area (m^2) of the building, which must be measured from the inside of the external walls. Distances to interior walls are measured on center. This value impacts savings calculations.

Table 6: Area Details in Retail

Building Type	*Indoor Space Type*	*Description*
RETAIL	Anchor Store Area (Supermarket)	Area of the supermarket. For any other type of anchor store, use the next field.
	Anchor Store Area (Other)	Area of the anchor store for any anchor store type except a supermarket.
	Atrium	An entrance hall or central court with a high ceiling. Many shopping mall layouts have an atrium to ventilate and provide natural light to the common areas and corridors of the mall.
	Bakery	Sales and preparation area including ovens for baked goods.
	Bathrooms	As commonly understood
	Bulk Storage	As commonly understood
	Car Parking	As commonly understood
	Cold Storage Area	As commonly understood
	Controlled Storage	Conditioned storage area
	Corridors and Lobby	As commonly understood
	Dispatcher	Dispatch area
	Dry Storage	As commonly understood
	Electronics Area	Sales area for electronics
	Food Court	Includes seating area for customers to dine in
	Food Sales	As commonly understood
	Frozen Section	Frozen displays

Building Type	*Indoor Space Type*	*Description*
	Frozen Storage	Frozen back storage
	General Sales Area	As commonly understood
	In-line Store Area	Shops in a row in a mall
	Inventory Area	Storage area
	Inventory Control	Area for checking inventory before it goes to storage
	Leisure & Entertainment	As commonly understood
	Mall Area (Communal Corridors)	Includes the communal corridors in a shopping mall
	Mechanical & Electrical Room	As commonly understood
	Offices	Office area
	Office Space(s)	Area of the offices in the "light industry" and "warehouse" models
	Package Assembly	As commonly understood
	Package Disassembly	As commonly understood
	Production Area	As commonly understood
	Rack Storage	As commonly understood
	Receiving Area	As commonly understood
	Receiving and Shipping	As commonly understood
	Refrigerated Area	As commonly understood
	Shipping Area	As commonly understood
	Supermarket	This option appears in the "department store" model, the "small food retail" model, and the "non-food big box retail" model, and refers to a supermarket within a retail complex. When the entire retail building is a supermarket, the "supermarket" model should be selected instead. In shopping malls, the supermarket is an option as the anchor store.

Offices

- Gross Internal Area Excluding Car Parking – The total internal area of the office building. This includes the offices, conference rooms, corridors, lobby, bathrooms, M&E rooms and food court. Calculate and enter the total area (m²) of the building, which must be measured from the inside of the external walls. Distances to interior walls are measured on center. This value impacts savings calculations.
- Floors Above Grade – The total number of floors above the ground level.
- Floor-to-Floor Height – The total floor-to-floor height, including the height of the slab. Use a weighted average for buildings with varying floor heights.
- Occupancy Density – The typical full-time equivalent occupancy during the occupied hours.
- Operational Hours – The typical weekday operational hours.
- Working Days – The days of week that the building will be functional.
- Holidays - The average number of holidays (not including weekends) during the year.
- Food Court – Select if the building has a Food Court. Note that an office pantry does not qualify in this category.
- Cellular Office – Select if the building does not have an open plan system and employees work in separate rooms.

Table 7: Area Details in Offices

Building Type	*Indoor Space Type*	*Description*
Office	Open Plan Office (m²)	A default value (m²) is provided. If the actual area differs from the default, then enter it here.
	Cellular Office (m²)	As commonly understood
	Corridors (m²)	As commonly understood
	Conference Rooms (m²)	As commonly understood
	Lobby (m²)	As commonly understood
	Bathrooms (m²)	As commonly understood
	M&E Rooms, Store ** (m²)	This field is equal to the remaining space required to total the Gross Internal Area (m²). This value is automatically calculated and cannot be overwritten.

Hospitals

- Type of Hospital – Enter the specific type or category of the hospital. Common types of hospitals are nursing home, private, public and teaching hospitals, multi-specialty hospital, clinic (outpatient), diagnostic center, eye and dental hospital.
- Average Occupancy Rate – Enter the average percentage of rooms within the hospital that are occupied by patients.
- Select the type of amenities and services that the hospital facility provides:
  - Irrigated Area - Check the box if the project contains planted area(s) to be irrigated. Enter the area that needs irrigation.
  - Laundry
  - Kitchen
- Floors Above Grade – Enter the total number of floors above the ground level.
- Floors Below Grade – Enter the total number of floors below the ground level.
- Floor-to-Floor Height - The total floor-to-floor height, including the height of the slab. Use a weighted average for buildings with varying floor heights.
- Beds - Enter the total number of beds available in the hospital. This does not apply for outpatient hospitals, such as nursing home, clinic (outpatient), diagnostic center, eye and dental hospital.
- Gross Internal Area (m^2) – Enter the internal area of all the spaces of the hospital, including patient areas, operating and consultation rooms, offices, corridors, special rooms (i.e. ICU), mechanical and electrical and services (i.e. kitchen or dining). The total area (m^2) of the building must be measured from the inside of the external walls. Distances to interior walls are measured on center. This value impacts savings calculations. This only applies to outpatient hospitals, such as nursing home, clinic (outpatient), diagnostic center, eye and dental hospital.

Table 8: Area Details in Hospitals

Building Type	*Indoor Space Type*	*Description*
HOSPITALS	Patient Areas - General (m^2)	As commonly understood
	Patient Areas - Specialty Wards (m^2)	As commonly understood
	Intensive Care Units (ICUs) (m^2)	As commonly understood
	Pre- & Post-Operating Rooms (m^2)	As commonly understood
	Operating Rooms (m^2)	As commonly understood
	Consultation Rooms (m^2)	As commonly understood
	Therapy Rooms (m^2)	As commonly understood

Building Type	*Indoor Space Type*	*Description*
	Diagnostic Services (m^2)	As commonly understood
	Offices (m^2)	As commonly understood
	Corridors (m^2)	As commonly understood
	Central Sterile Supply Department (m^2)	As commonly understood
	Mechanical & Electrical Rooms (m^2)	As commonly understood
	Bathrooms/Storage (m^2)	As commonly understood
	Kitchen & Food Preparation (m^2)	As commonly understood
	Laundry (m^2)	As commonly understood
	Car Parking(m^2)	As commonly understood
	Dining (m^2)	As commonly understood
	Waiting Areas (m^2)	As commonly understood
	Education/Auditorium (m^2)	As commonly understood

Education

- Type of Educational Facility – The specific type or category of educational facility. The available options are pre-school, school, university, sport facilities and other educational facilities.
    - 'Pre-school' refers to informal play schools.
    - 'School' refers to formal schools from elementary to senior years.
    - 'University' refers to higher education institutions following the school years, such as colleges and university campuses.
    - 'Sport facilities' include stadiums and stand-alone gymnasiums.
    - 'Other educational facilities' may include training centers or places of worship.

- Occupancy Density – The ratio of the total enclosed area to the number of students at the facility, expressed in m^2/student.

- Operational Hours – The number of hours that the facility is operational on a working day, expressed in hours per day.

- Working Days – The number of days in a typical working week that the facility is operational, expressed in days per week.

- Holidays – The number of days in a year that the facility is closed for holidays, not including weekends.

- Select the type of amenities and services that the educational facility provides (irrigated area, and/or swimming pool).

- Floors Above Grade – The total number of floors at and above the ground level.
    - For buildings with a different number of floors in different areas, use the weighted average number of floors.
    - For projects being modeled in sections with multiple EDGE models, the Floors field must only show the number of Floors that section represents. For example, if residential units are being modeled separately, the Floors field must show only the number of Floors for that unit.
- Floors Below Grade – The total number of floors below the ground level. The same logic applies as for Floors Above Ground (see immediately above) for a different number of floors in different areas.
- Floor-to-Floor height – The total floor-to-floor height, including the height of the slab. Use a weighted average for buildings with varying floor heights.
- Gross Internal Area (m^2) – The total internal area of all the spaces of the educational facility.
    - Calculate and enter the total area (m^2) of the building, which must be measured from the inside of the external walls. Distances to interior walls are measured on center. This value impacts savings calculations.
    - This includes all the spaces covered under the Area Details, such as classrooms, play rooms, meeting rooms, labs, offices/administration rooms, staff rooms, auditoriums, library, computer rooms, worship places, corridors, sports room, changing rooms, workshops, restrooms, cafeteria, other space types, and indoor car parking.

Table 9: Area Details in Education buildings

Building Type	*Indoor Space Type*	*Description*
EDUCATION	Auditoriums	As commonly understood
	Cafeteria	As commonly understood
	Changing Rooms	Rooms adjacent to the gymnasium or swimming pool for changing clothes, often equipped with showers
	Classrooms	As commonly understood
	Computer Rooms	As commonly understood
	Corridors	As commonly understood
	Indoor Car Parking	Covered parking area that is part of the educational facility being modeled
	Labs	Laboratories such as a chemistry lab
	Library	As commonly understood
	Meeting Rooms	Area of the rooms used for occasional meetings or conferences

Building Type	*Indoor Space Type*	*Description*
	Offices/Administration Rooms	Administrative spaces
	Other Space Types	Any indoor areas not covered by the other categories provided
	Play Rooms	As commonly understood
	Restrooms	Area with toilets and washbasins
	Sports Rooms	Areas for indoor sports such as indoor gymnasiums
	Staff Rooms	Area for staff to gather for meetings, lunch or events
	Workshops	Area of the rooms used as workshops such as for carpentry or theater
	Worship Places	As commonly understood

Building Orientation

This section does not apply to Homes or Hospitality in EDGE version 2. This section applies to Retail, Offices, Hospitals and Education building types.

The parameters "floor plan depth" and "main orientation" described below are used to estimate the dimensions and orientation of a building, which will have a direct effect on the energy consumption of the building.

- Floor plan depth (m) – This is the average width of the building measured perpendicular to the main façade of the building. A default value is provided based on a typical aspect ratio. If the actual floor plan depth differs from the default, then enter it in the User Entry provided.
- Main orientation – This is the direction that the longest façade of the building faces. Select the direction that the building's longest façade faces from the drop-down menu. EDGE predicts the solar heating loads based on this orientation, which is reflected as cooling or heating energy in the energy chart. If the exact details of the dimensions and orientation are available, then complete the User Entry fields in the Building Lengths section.
- Building lengths – Based on the earlier selections and entered total area, the building lengths in each orientation are provided by default. For most buildings, it is recommended that the user fields under "building lengths" should be left blank to let the software use default values. The exception is if the building is a regular box shape with no angles or cut-outs and actual values are known. Then, they can be entered under Building Lengths in the "User Entry" section. All façade lengths in one orientation should be added up, e.g. if there are three north facing exterior wall segments, they should be added up before entering here.

The direction of any façade is the direction that its windows face to the outside when seen from above; in other words, if a line is drawn perpendicular to the length of the wall with the arrow pointing to the outside in Plan View, the direction in which the arrow is pointing defines the orientation. For example, a wall whose windows look out to the north-east has a north-east orientation.

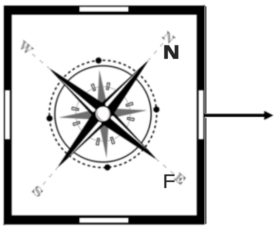


Figure 2. Building orientation

Note that when the building orientation is changed in EDGE, the default Building Lengths are also swapped automatically. However, if these fields contain User Entries, the Building Lengths are not swapped automatically; they should be corrected manually if changing the orientation.

Building Systems

The information in this section is used to calculate the improved case performance for the project building.

- Does the building design include an AC system? – Select "Yes" if the building will be delivered with an air conditioning (AC) system, or "No" if air conditioning system will NOT be installed at the time of final EDGE certification. Air conditioning systems include roof-top units, through-the-wall unitary air conditioners, packaged air conditioning units and chillers. They do not include ceiling fans or natural ventilation.

  If "No" is selected but EDGE predicts that the building is likely to require cooling, then the cooling load will be reflected as virtual energy. This is described in the Building Systems section of the Design Page Guidance.

  Does building design include space heating? – Select "Yes" if the building will be delivered with a space heating system at the time of final EDGE certification, or "No" if heating system will NOT be installed. Space heating in EDGE refers to building-wide heating systems such as underfloor, radiant, heat-exchangers, permanent gas heaters, etc. and includes appliance heaters using gas or electricity. Space heating does not include wood or fossil fuel burning fireplaces.

  If "No" is selected but EDGE predicts that the building is likely to require heating, then the heating load will be reflected as virtual energy. As mentioned previously, this is described in the Building Systems section of the Design Page Guidance.

Advanced Settings: Key Assumptions for the Base Case

The default values shown under the key assumptions are used to calculate the base case performance of a building.

EDGE uses the best available information for default values. Since energy and water rates can change with time or location, EDGE provides users with the ability to update the default values for a project. If any of the values are overwritten, justification must be provided in the form of supporting documentation, including a link to any relevant local standards.

It should be noted that certain baseline definition values are locked for general users and only accessible to admin users. For example, the baseline value for the heating system efficiency is visible but locked. These values can be updated if a different minimum efficiency is required by the building and energy codes or local mandates are in place applicable to the project. Please contact the EDGE Team to adjust these values, with relevant documentation to support the request.

- Fuel Used for Electric Generator – The actual fuel used in the project must be selected from the dropdown menu.
- Fuel Used for Hot Water Generation – The actual fuel used in the project must be selected from the dropdown menu. If a hot water system is not part of the project, "None" must be selected.
- Fuel Used for Cooking – The actual fuel used in the project must be selected from the dropdown menu.
- Fuel Used for Space Heating – The actual fuel used in the project must be selected from the dropdown menu. If no space heating is being provided, this selection must be "Electricity."
- % of Electricity Generation Using Diesel – This is the percentage of the annual average electricity consumption for the building that uses a diesel generator as the source for electricity. Update the value if the actual electricity generation from diesel is different than the default.
- Cost of Electricity – Annual average cost of electricity per kilowatt-hour. The default cost for electricity appears for the selected country. Update the value if more accurate data is available.
- Cost of Diesel Fuel – Annual average cost of diesel per liter.
- Cost of LPG/Natural Gas – Annual average cost of natural gas per liter.
- Cost of Water – Annual average cost of water per kilo-liter.
- CO_2 Emissions from Electricity Generation – EDGE provides a default emissions value in grams per kilowatt-hour (g/kWh) based on World Bank Group-approved emissions factors. Update the value if better data is available for the electricity grid serving the project location.
- Window to Wall Ratio – The proportion of total glazed area including frames to the gross area of the exterior wall. Glazed area may include windows, doors and curtain walls. Note that the window to wall ratio in the Key Assumptions reflects local building regulations or typical practice in the selected city. This value is locked. Contact the EDGE Team to update this baseline percentage if a specific window to wall ratio is encouraged or required for the project by code.

- Solar Reflectivity for Paint – Wall – Also known as albedo, this is the percentage of the full solar spectrum that is reflected by the exterior wall finish on average over the year. The default baseline value is 0.3 or 30%. Contact the EDGE Team to update this baseline percentage if a different minimum albedo is required for the project by code.

- Solar Reflectivity for Paint – Roof – Also known as albedo, this is the percentage of the full solar spectrum that is reflected by the roof finish on average over the year. The default baseline value is 0.3 or 30%. Contact the EDGE Team to update this baseline percentage if a different minimum albedo is required for the project by code.

- Roof U-value – The conductance of the baseline roof. Contact the EDGE Team to update this value if local standards or regulations stipulate a different maximum U-value for the roof.

- Wall U-value – The conductance of the baseline wall. Contact the EDGE Team to update this value if local standards or regulations stipulate a different maximum U-value for the walls.

- Glass U-value – The conductance of the baseline glazing (not including the frame). Contact the EDGE Team to update this value if local standards or regulations stipulate a different maximum U-value for the windows.

- Glass SHGC – The solar heat gain coefficient of the glazing (not including the frame). Contact the EDGE Team to update this value if local standards or regulations stipulate a different maximum Solar Heat Gain Coefficient (SHGC) for the glazing.

- Cooling System – This is the default cooling system assigned by EDGE based on the selected building type and size and heating fuel as per ASHRAE guidelines (see **Table 10**).

- AC System Efficiency – This is the baseline COP value of the air conditioning system. It is based on the default efficiency of the assigned system as per Section 6.4 of the ASHRAE standard 90.1-2007. Contact the EDGE Team to update this value if a different level of performance is required by code.

Table 10: Base Case System Type Selection[2]

Building Type	Fossil Fuel, Fossil/Electric Hybrid, and Purchased Heat	Electric and other
1. **Residential**	System 1 - PTAC	System 2 - PTHP
2. **Nonresidential and 3 floors or less and <2,300m²**	System 3 – PSZ-AC	System 4 – PSZ-HP
3. **Nonresidential and 4 or 5 floors and <2,300m² or 5 floors or less and 2,300m² to 14,000m²**	System 5 - Packaged VAV with reheat	System 6 – Packaged VAV with PFP boxes
4. **Nonresidential and more than 5 floors or >14,000m²**	System 7 - VAV with reheat	System 8 – VAV with PFP boxes

[2] Source: ASHRAE 90.1 2007. Table G3.1.1A

Table 11: Base Case System Description[3]

System No.	System Type	Fan Control	Cooling Type	Heating Type
1. **PTAC**	Packaged Terminal Air Conditioner	Constant Volume	Direct expansion	Hot water fossil fuel boiler
2. **PTHP**	Packaged Terminal Heat Pump	Constant Volume	Direct expansion	Electric heat pump
3. **PSZ-AC**	Packaged Rooftop Air Conditioner	Constant Volume	Direct expansion	Fossil fuel furnace
4. **PSZ-HP**	Packaged Rooftop Heat Pump	Constant Volume	Direct expansion	Electric heat pump
5. **Packaged VAV with Reheat**	Packaged Rooftop VAV with Reheat	VAV	Direct expansion	Hot water fossil fuel boiler
6. **Packaged VAV with PFP Boxes**	Packaged Rooftop VAV with Reheat	VAV	Direct expansion	Electric resistance
7. **VAV with Reheat**	Packaged Rooftop VAV with Reheat	VAV	Chilled water	Hot water fossil fuel boiler
8. **VAV with PFP Boxes**	VAV with Reheat	VAV	Chilled water	Electric resistance

- Heating System – This is the default heating system assigned as per ASHRAE guidelines (Table 11 above) based on the selected building type and size and heating fuel as per ASHRAE guidelines (see Table 10).

- Heating System Efficiency – This is the baseline COP value of the heating system assigned in the field directly above. It is based on the default efficiency of the assigned system as per Section 6.4 of the ASHRAE standard 90.1-2007. Contact the EDGE Team to update this value if a different level of performance is required by code.

- Monthly Average Outdoor Temperature (deg. C) – The monthly average outdoor temperature has only been included for the cities listed for each country. If the project site is not within a listed city, then enter the average monthly temperatures for the actual location. Additionally, for cities included in EDGE, due to microclimates, it is understood that the monthly temperatures for the project site may vary from the average temperatures for the city. For EDGE certification, the source for any temperature inputs must be submitted for compliance purposes. The following weather data sources are acceptable:
    - A Test Reference Year (TRY) if the building location is within 50km of a TRY location; or,
    - In the absence of local TRY weather data, an actual year of recorded weather data from a location within 50km of the building location; or,

[3] Source: ASHRAE 90.1 2007. Table G3.1.1B

  - In the absence of TRY or actual weather data within 50km, interpolated data based upon three points within 250km of the building location.
  - Weather data can be obtained using sources such as Meteonorm or Weather analytics.

- Latitude – The latitude for the selected city is provided by default. If the building is outside of the selected city, then the actual latitude of the site can be entered here.
- Average Annual Rainfall – The average annual rainfall for the selected city is provided by default. Update these values if better data is available for the project location.

GREEN MEASURES OVERVIEW

This section provides an overview of the policies related to efficiency measures in EDGE.

Required Measures

In EDGE, required measures are defined differently from the typical understanding of a required measure. Required measures in EDGE do not mean that EDGE requires that the measures must be implemented, or that the improved case must meet or exceed the baseline case. Rather, it means that the actual performance of the measure is required to be entered in EDGE *if that measure is present in the project*. If the performance of the installed components varies across the project for any reason, then a weighted average of the performance metric must be used. If the measure is not present in the project, then the requirement does not apply. For example, if a residential project has air-conditioners, the actual COP of the air-conditioners is required to be entered. If the COP varies from one room to another, a weighted average COP must be used. For buildings with an air-conditioning system, at least one of the air-conditioning options must be selected (but not all of them). But if the project does not include air-conditioning, then the measure can be left blank.

The examples in Table 12 explain how to address the measures in EDGE that are required and marked with an asterisk (*), versus those that are not.

Table 12: Required versus voluntary measures in EDGE

Measure ID	How to address in software	How to address at audit
E01* ***(asterisk) indicates that the input is Required**	Required to be selected and filled, regardless of whether the measure generates savings or affects the project in a negative way. Exceptions: 1. If a measure is not present in the project 2. In the case of walls and roof, the measure is only required when the U-value of the base case is less than 0.5 W/m^{2}K; and in the case of windows, when the U-value of the base case is less than 3 W/m^{2}K. Higher base case values indicate that the local standards are not strict, therefore the measure becomes voluntary in EDGE.	Must be reviewed in all projects to ensure that it has been selected and the actual value as per design or construction has been entered.
E02	Optional; to be selected only if targeted for savings	Only reviewed if selected

Results

The Results bar is a summary of the Key Performance Indicators (KPIs) calculated by EDGE. To calculate performance against these indicators, EDGE makes assumptions on how the building will be used by the occupants. Since the actual usage patterns may differ depending on occupant consumption, the water and energy usage and subsequent costs may vary from EDGE predictions. The KPIs include:

- Final Energy Use – the energy consumption (in kWh/month) for the project is calculated automatically by EDGE, based on the data entered in the Design section and any reduction achieved through the selection of efficiency measures.

- Final Water Use – the water consumption (in kL/month) for the project is calculated automatically by EDGE, based on the data entered in the Design section and any reduction achieved through the selection of water efficiency measures.

- Operational CO_2 Savings – EDGE automatically calculates the CO_2 savings (in tCO_2/year) based on the final energy use multiplied by the CO_2 emission factor for the generation of grid electricity. The default value for the selected country's CO_2 emissions is shown in the Design section but can be overwritten if evidence can be provided to support it. The evidence must be from a reliable source such as a peer-reviewed publication from an international organization or a specialized government-approved study.

- Embodied Energy Savings – EDGE automatically calculates the embodied energy savings (in mega joules) from the building dimensions and the materials selected in the Materials section.

- Base Case Utility Cost – EDGE projects the monthly cost (in USD/month or local currency in specific countries) for energy and water use.

- Utility Costs Reduction – EDGE projects the monthly savings (in USD/month or local currency in specific countries) in utility bills.

- Incremental Cost – Additional cost of implementing the selected efficiency measures (in USD or local currency in specific countries). Certain building measures may contribute to a lower overall cost compared to the baseline. Therefore, negative incremental costs are possible. EDGE cost data is based on average global data and is continuously being refined. It is only meant as a guidance tool for comparison between measures. If specific local data is available, the use of it in a more specific financial model is encouraged for making financial decisions.

- Payback in Years – Number of years to repay the incremental cost compared to the cost savings of utilities. The method used is simple payback based on the capital cost of the measure.

Energy and Water

The selection of energy and water efficiency measures can have a significant impact on the resource demand of a building. When measures are selected, EDGE makes default assumptions on the typical improved performance over the base case. Note that the default must be overwritten with actual values where applicable by editing the user input fields.

While onsite renewable energy and the collection of rainwater are not technically efficiency measures, they will reduce the use of grid electricity and treated potable water respectively, contributing to the 20% efficiency savings target required to reach the EDGE standard. Other innovative measures impacting energy or water savings can be reported using a proxy measure (by selecting a substitute from the options available in EDGE) and will be evaluated on a case by case basis.

EDGE currently uses delivered energy (i.e., that paid for by the consumer) as the measure of efficiency, as it is a more consistent global indicator. The carbon dioxide emissions (global warming potential) related to delivered energy use is a more accurate measure of the impact of a building on the environment, so future versions of EDGE may consider using this alternative indicator.

The results for both energy and water are shown in charts that compare the base case building with the improved case.

Energy

The energy chart shows a breakdown of the end uses that consume energy. The units are kWh/m²/year. This includes the energy from all fuels – including electricity, natural gas and diesel – converted to kilowatt-hours. Hovering on the bar graph sections displays more information about each section. Note that Figure 3 shows 'Virtual Energy' for cooling and fans because the building does not include a cooling system.

Virtual Energy

The use of Virtual Energy is a key concept in EDGE. When there are no plans for HVAC to be installed in a building at the time of certification, EDGE calculates the energy that will be required to ensure human comfort on the premise that if the building design does not provide proper internal conditions and the space is uncomfortably hot or cold, eventually mechanical systems will be added to the building (in the form of individual air conditioning units, for example) to compensate for the lack of a space-conditioning system. This future required energy for comfort is demonstrated in EDGE as "virtual energy," articulated separately for ease of understanding.

While this virtual energy is not reflected in the utility costs, it is used by EDGE to determine the 20% improvement in energy efficiency required by EDGE. Therefore, virtual energy must be reduced in the same way that actual energy is reduced.

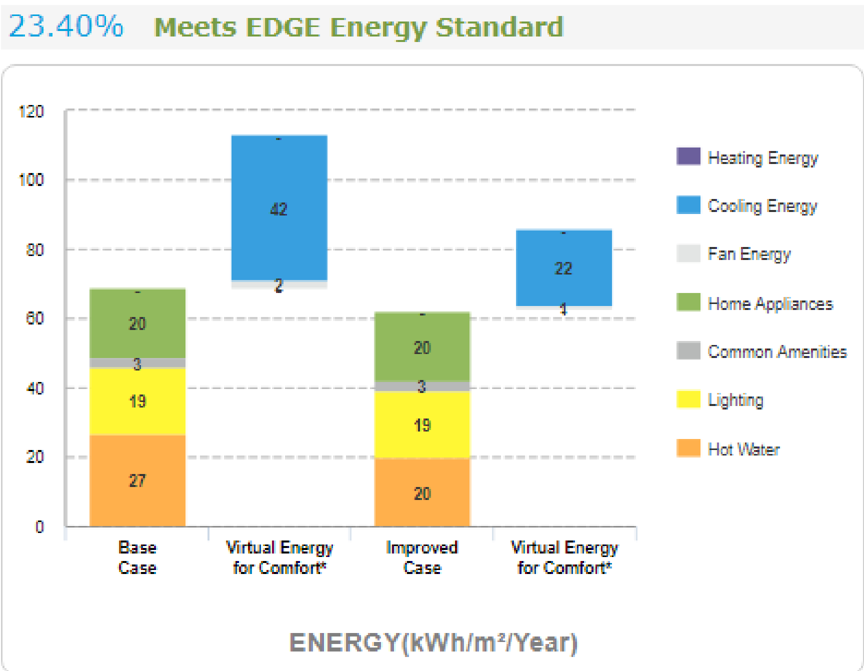


Figure 3. Sample Energy chart from the Home typology

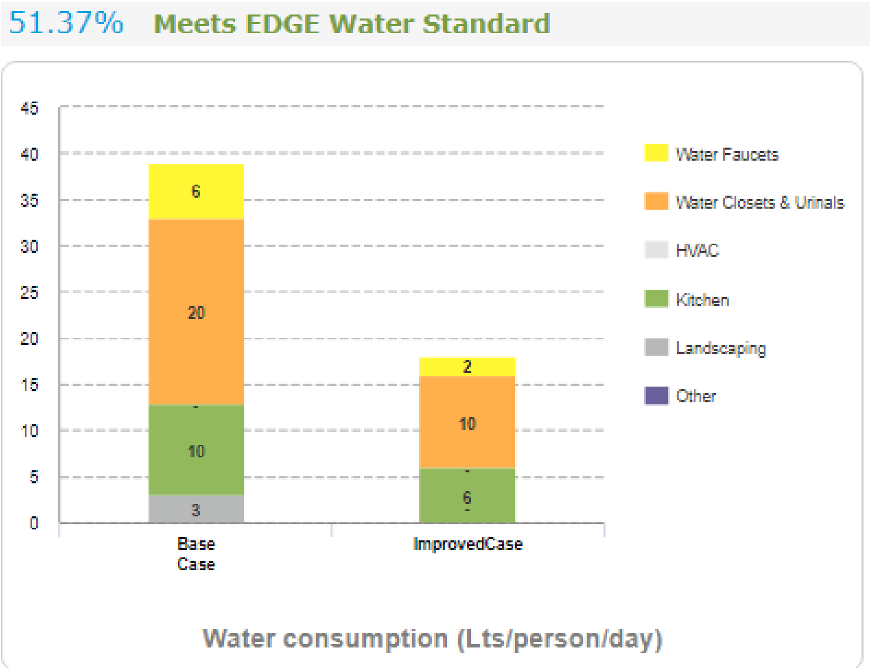
The categories in the Energy Chart vary depending on the building type. A description of the categories follows.

- Heating Energy, Cooling Energy and Fan Energy: These reflect the energy used in the space conditioning systems. When a cooling or heating system is not specified, but the building requires it to maintain comfort, the estimated heating or cooling energy and its related fan energy show up as "virtual energy" on the Energy Chart. An example of virtual cooling and related fan energy is shown in Figure 3.
- Catering: (Hospitality, Hospitals) Includes cooking equipment, refrigerator, kitchen equipment and extractor hoods
- Equipment, Lift, STP, Water Pumps: (Hospitals) Includes plug loads, miscellaneous equipment, elevators, and sewage treatment plant (STP), and water pumps.
- Food Court: Includes cooking equipment, refrigerator, kitchen equipment and extractor hoods, as well energy required for the hot water for cooking.

  It is only displayed if the 'food court' space type is selected as a facility in the design section. This space type only applies to professional kitchens and should not be made for small pantries such as those on office floors.
- Home Appliances: (Homes) Plug loads from common appliances
- Hot Water: Energy consumed by the hot water system. Heating with any fuel type is converted to kWh.
- Laundry: This is the energy involved in washing and drying clothes.
- Lighting: This is the energy used for the lights.
- Pump Energy: Only includes pumps dedicated to the HVAC system.
- Refrigeration: (Retail) This is the energy involved in keeping the food refrigerated.
- Other: This includes plug loads, miscellaneous equipment, elevators, sewage treatment plant (STP) and water pumps.
- Common Amenities: (Homes) These include the sewage treatment plant (STP), water treatment plant (WTP), grey water treatment plant, water pumps for recreational facilities (such as a swimming pool), and the lift.

Water

The water chart shows a breakdown of the end uses that consume water. The units are cubic meters per day. Hovering on the bar graph sections displays more information about each section.



The categories in the Water Chart vary depending on the building type. A description of the categories follows.

Figure 4. Sample Water Chart from the Retail typology

- Cafeteria: (Hospitality) This includes dishwashers, pre-rinse spray valves, kitchen sink, and water used for cooking and drinking in professional kitchens.

- Food Court / Kitchenette: (Offices) This includes dishwasher, pre-rinse valve, kitchen sink, water for drinking and cooking in professional kitchens.

  It is only displayed if the 'food court' space type is selected as a facility in the design section. This space type only applies to professional kitchens and should not be made for small pantries such as those on office floors.

- HVAC: (Retail, Offices, Hospitals, Education) This includes the water used for cooling and/or heating equipment.

- Kitchen: (Retail, Hospitals) This includes dishwashers, pre-rinse spray valves, kitchen sink, water used for cooking and drinking.

- Landscaping

- Laundry: (Hospitality, Hospitals) This includes cleaning the building, washing clothes, and car washing.

- Other: (Offices) This includes water for cleaning the building.

- Public Area: (Hospitality) This includes the water closets, urinals and faucets of the banquet hall, and employees and public areas of the hotel.

- Water Closets and Urinals

- Water Faucets

- Shower

- Swimming Pool

Materials

A list of relevant specifications for each building element (roof, external walls, internal walls, floor finishes, etc.) appears in the Materials section. For each building element, a specification must be selected from the drop-down list that is most similar to the specification used in the design. Where there are multiple specifications for each building element, the predominant specification should be selected. Thicknesses must be indicated for floor slabs, roof construction, external walls and internal walls.

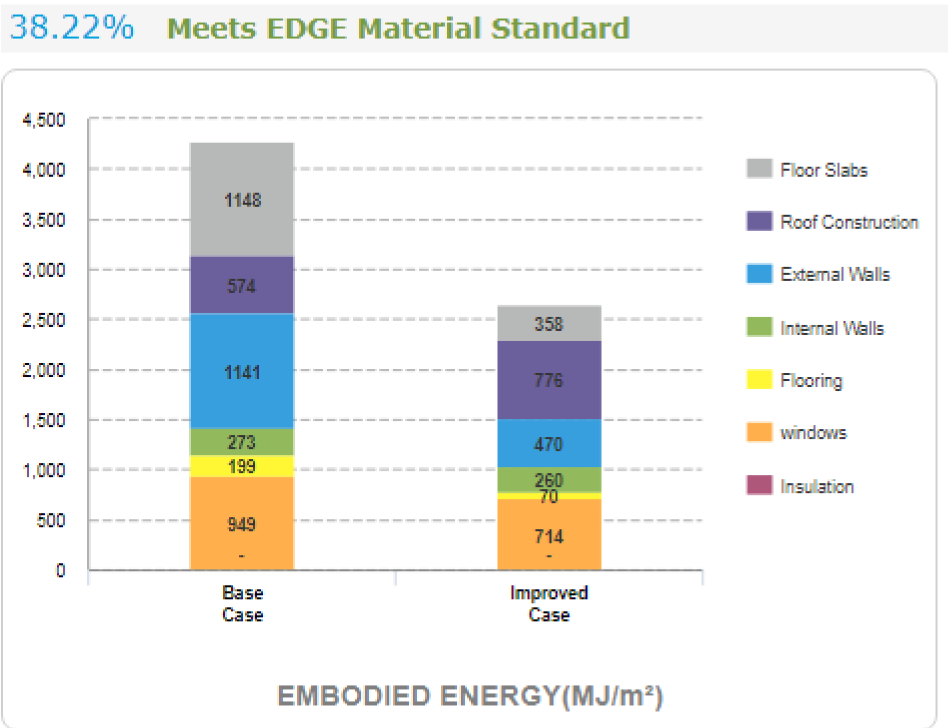


Figure 5. Sample Materials Chart from the Offices typology

As seen in Figure 5, the indicator used to measure materials efficiency is the embodied energy of the specifications used. The embodied energy of a product is the primary energy demand for its production. As with energy efficiency measures, future versions of EDGE may consider using carbon dioxide (global warming potential) as an indicator of materials efficiency as this more closely reflects the impact of the building on the environment.

INDIVIDUAL MEASURES IN EDGE

The Individual Measures Section in the user guide describes each measure included in EDGE, indicating why the measure has been included, how it is assessed, and what assumptions have been made to calculate the base case and improved case. The guidance for each EDGE measure contains the subsections described below:

Requirement Summary

A brief summary of the system or level of performance required before the measure can be claimed.

Intention

What the measure aims to achieve and why it is measured in the way that it is.

Approach/Methodologies

The different approaches, which can be used to assess the design, are provided with an explanation of the calculations and terminology used.

Potential Technologies/Strategies

The possible solutions and technologies that might be considered by the design team to meet measure requirements.

Relationship to Other Measures

EDGE predicts energy, water and materials efficiencies by taking a holistic view of the information that has been provided about the building project. The strong relationship between certain measures is revealed to clarify EDGE calculations and support the overall design process.

Assumptions

EDGE makes assumptions for a base case building. The base case is taken from either typical practice or performance levels required by applicable local codes and standards. An assumption is also made for the improved case, so that when a measure is selected the predicted performance of the building is improved. Often it is possible to override improved case assumptions with more accurate levels of predicted performance for the actual building design. This allows improvements to be recognized if the assumed improved case level is not met and calculates additional reductions if the design exceeds the improved case.

Compliance Guidance

The compliance guidance provided for each measure indicates the documentation that will be required to demonstrate compliance, should the project owner be striving for EDGE certification. Specific documentation varies according to the technology being assessed.

Because available evidence depends on the current stage in the process, EDGE provides compliance guidance for each measure at both the design and post-construction stages. If the required evidence is not available during the design stage, a signed declaration of intent can be provided by the project administrator. Note that later at the post-construction stage, this must be signed by the client or a designated client representative as defined in the certification agreement. During the post-construction stage, more rigorous documentation is required. However, a common-sense approach is recommended to verify that the measure has indeed been installed as per the specifications claimed. For example, some measures require a bill of quantities to demonstrate compliance. This would be the document used in the tendering of construction, comprising a list of the materials required for the works and their estimated quantities. If that document is not available, similar locally used documents such as drawings or invoices may be used instead to verify the construction details.

In most cases, a minimum of 90% of a particular specification must comply for certification, unless specifically stated. If the auditor has reason to believe that a measure should be recognized, then proper justification should be provided for the certifier's review. Approval of such justification is at the discretion of the certifier.

ENERGY EFFICIENCY MEASURES

Energy efficiency is one of the three main resource categories that comprise the EDGE standard. To comply for certification purposes, the design and construction team must review the requirements for selected measures as indicated and provide the information.

Note: Efficiency values used in this User Guide to describe a measure are global baseline assumptions and may differ from values used in EDGE for countries in which it has been calibrated.

The following pages explain each energy efficiency measure by relaying the intention, approach, assumptions and compliance guidance requirements.

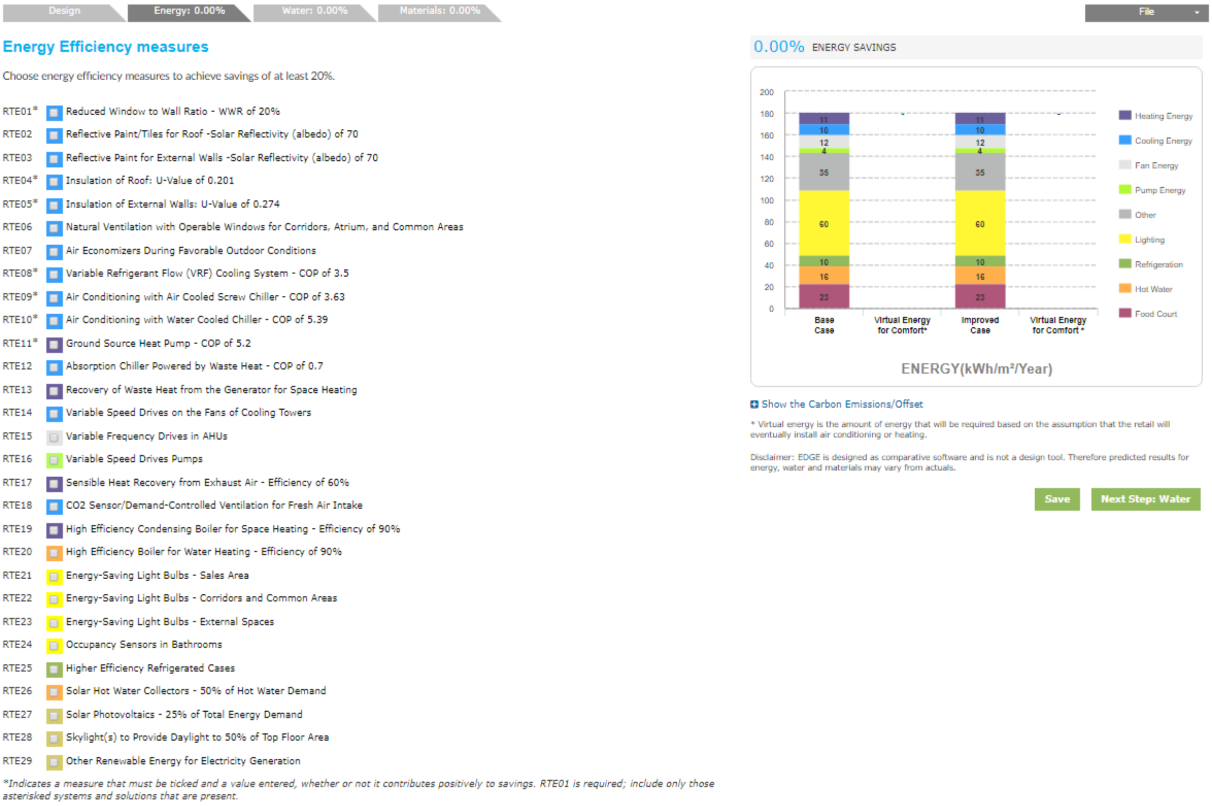


Figure 6. Screenshot of energy saving measures of one building type in the EDGE App

E01* - REDUCED WINDOW TO WALL RATIO

Corresponds to HME01, HTE01, RTE01, OFE01, HSE01, EDE01

Requirement Summary

Window-to-Wall Ratio (WWR) should be selected and the WWR value entered in the EDGE App in all cases, irrespective of the value. Savings can be achieved if the Window to Wall Ratio is lower than the local base case as set out in the Key Assumptions for the Base Case in the Design section. EDGE will calculate the impact of any improvement beyond the base case.

Intention

The sun is the most powerful light source but is also a source of significant heat gain. Therefore, it is important to balance lighting and ventilation benefits of glazing against the impacts of heat gain on cooling needs and/or passive heating. Finding the correct balance between the transparent (glass) and the opaque surfaces in the external façades helps to maximize daylight while minimizing unwanted heat transfer, resulting in reduced energy consumption. The design goal should be to meet minimum illumination levels without significantly exceeding the solar heat gains in temperate and warm climates, as well as to make the most of passive heating in cold climates in winter time.

Windows generally transmit heat into the building at a higher rate than walls do. In fact, windows are usually the weakest link in the building envelope as glass has much lower resistance to heat flow than other building materials. Heat flows out through a glazed window more than 10 times faster than it does through a well-insulated wall. While glazed areas are desirable to admit solar radiation in cold climates during the day, windows in warmer climates can significantly increase the building's cooling loads.

Approach/Methodologies

This measure uses the Window to Wall Ratio (WWR), which is defined as the ratio of the total area of the window or other glazing area (including mullions and frames) divided by the gross exterior wall area.

The WWR is calculated with the following equation:

$$\mathrm{WWR}\ (\%) = \frac{\sum \text{Glazing area}\ (\mathrm{m}^2)}{\sum \text{Gross exterior wall area}\ (\mathrm{m}^2)}$$

Glazing area is the area of glass on all façades regardless of orientation. Gross exterior wall area is the sum of the area of the exterior façades in all orientations, which includes walls, windows and doors.

The actual WWR for the design case must be entered in the system. While a higher WWR may have a negative impact on energy savings, it can be compensated for by other energy saving measures.

The improved case WWR must be calculated and entered for each façade separately, i.e. for the North Façade the % WWR of the North façade only should be entered. This will impact the solar gain in each façade and impact the cooling and heating load.

For projects with multiple subprojects with multiple EDGE files, the recommended method is to calculate an average WWR for the whole building and use that in every subproject. Modeling each subproject with its own WWR is also acceptable, but unless a significant difference exists between the subprojects with some containing double height spaces or very different glass areas, this approach is not recommended. For example, if the average WWR of a residential building is 35%, that will be used for all unit types regardless of their individual WWR. (However, individual window opening sizes will be considered for the natural ventilation measure).

Windows and walls facing internal courtyards or gaps between buildings (open to outside air) should be included in the WWR calculations.

Spandrel panels (opaque insulated glass panels) should be included as external walls in the WWR calculations.

The following examples should be excluded from the calculations of WWR:

a) Walls with windows/ventilation openings into interior shafts only (for example, as seen for bathrooms in residential projects in India)
b) Any external wall that is not directly exposed to the environment. For example, underground walls, earth-bermed walls or walls in direct contact with another building
c) Walls that do not enclose interior spaces. This includes walls that have more than 30% of the area as a permanent opening for ventilation. The next enclosing wall should be used instead.
d) Openings that are only ventilation openings (without glazing)

Potential Technologies/Strategies

A building with a higher WWR will transfer more heat than a building with a lesser WWR. If the WWR is higher than the default value, then other measures such as shading or a lower solar heat gain coefficient (SHGC) of the glass should be considered to offset the energy loss. In cold climates, when the WWR is higher than the default, the insulation of glass using double or triple glazing should be considered.

With regards to daylight, two basic strategies are available for using the sun for lighting while minimizing heat gain. The first is to use a small window opening (15% WWR) to illuminate a surface inside the space that then spreads the light out over a large area. The second is to use a moderately sized window (30% WWR) that "sees" an exterior reflective surface but is shaded from the direct sun. To increase the daylight availability, the selection of higher visible light transmittance (VLT>50) for the glass is also important.

Relationship to Other Measures

Envelope heat transfer is a function of the thermal resistance of the external materials, the area of the building façade, and the temperature difference between the exterior and interior of the building. The primary causes of heat transfer are infiltration and windows. The size, number and orientation of windows have a significant effect on the building's energy use for thermal comfort purposes (heating or cooling).

In cold climates, direct solar radiation passes through the glass during the day, passively heating the interior. If sufficient thermal mass is used, this heat is then released, helping to keep the room comfortable later in the day. In this climate type, the glass placement that is most desirable is at the elevation with the greatest exposure to sunlight. However, in warm and temperate climates, the WWR should be lower as the reduction of glass leads to a reduction in the overall cooling load and reduced need for air conditioning.

It is important to consider that lighting and cooling energy use can be reduced by the use of daylighting. This should be balanced with the corresponding solar and convective heat gains.

Assumptions

The base case for the WWR is included in the Key Assumptions for the Base Case in the Design section. The base case varies by building type, and can also vary by location. The default assumptions for the improved case for the WWR may vary from country to country. If the actual WWR is different than the default, the actual WWR value for the improved case must be entered manually.

Compliance Guidance

At the post-construction stage, it is important to ensure that the WWR has been maintained to achieve the energy savings indicated in the EDGE results. Compliance is achieved when the design team can demonstrate that the WWR in all elevations is equal or lower than the claimed specification, using the formula explained in "Potential Technologies/Strategies" above.

Design Stage	Post-Construction Stage
At the design stage, the following must be used to demonstrate compliance: ▪ Calculation of "Glazing Area" and "Gross Exterior Wall Area" for each façade of the building and the average area weighted WWR; and ▪ All façade elevation drawings showing glazing dimensions and general building dimensions.	At the post-construction stage, the following must be used to demonstrate compliance: ▪ Updated WWR calculations if necessary, or confirmation that the design WWR is still valid; and, either ▪ As-built façade drawings; or ▪ External and internal photographs of the building showing all the elevations

E02 – EXTERNAL SHADING DEVICES

Corresponds to HME04, HTE02, RTE04, OFE04, HSE04, EDE04

Requirement Summary

This measure can be claimed if external shading devices are provided on the building's exterior.

Intention

External shading devices are provided on the building façade to protect the glazed elements (glass windows and doors) from direct solar radiation to reduce glare and to reduce radiant solar heat gain in cooling dominated climates. This method is more effective than internal shading devices such as blinds, because radiant solar gain occurs in the form of short wavelengths that can pass through glass. However, reflected wavelengths are longer and can no longer pass through glass to exit the space. This phenomenon is known as the greenhouse effect.

Approach/Methodologies

If this measure is selected, EDGE uses a default shading factor equivalent to that of a shading device that is 1/3 of the height of the window and 1/3 of the width of the window on all windows of the building. However, if shading devices are provided that are different from EDGE assumptions, then a different shading factor should be used. The shading factor varies according to the latitude and the orientation of the windows, as well as the size of the shading device, and can be calculated using the built-in calculator. Figure 7 illustrates the dimensions used to calculate the shading factor.

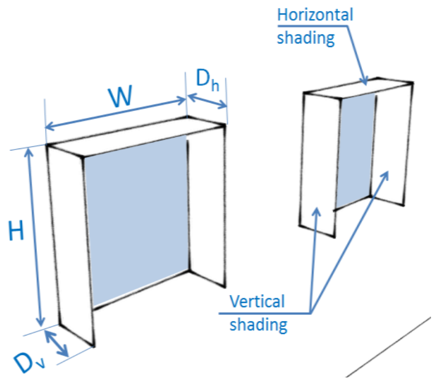


Figure 7. Illustration of the dimensions used to calculate the shading factor

Table 13, Table 14, and Table 15 show the relationship between the Dh and Dv (depth of horizontal and vertical shading) H (window height) and W (window width) to determine the shading factor.

This measure is assessed using an Annual Average Shading Factor, which is represented by one minus the ratio of solar radiation transmitted by a protected window (with external shading devices), compared to that transmitted by an unprotected window.

Annual Average Shading Factor (AASF) is defined by following equation:

$$\text{AASF} = 1 - \frac{\text{Total annual solar heat gain from a window with shading (kWh)}}{\text{Total annual solar heat gain from a window without shading (kWh)}}$$

The shading factor is expressed as a decimal value between 0 and 1. The higher the shading factor, the greater is the shading capability of the shading device.

Table 13, Table 14, and Table 15 indicate the shading factors for different orientations, latitudes, and shading device proportions. The last column of Table 15 lists the average shading factor for the combined type, which is used as the default improved case by EDGE.

The project AASF is the area-weighted average of the shading factors of all the external windows. When conducting calculations, all windows should be accounted for. If a window has a vertical and a horizontal overhang with different depths, select the more conservative (smaller factor) overhang depth for the calculation. If any windows do not have an overhang, they must still be included in the calculation and use the appropriate values for 'No Overhang.' The total Window Area must match the total External Window Area used in WWR calculations.

Table 13: Shading factors for horizontal shading devices at different latitudes for each orientation
*The shading factors have been derived using a solar modelling tool

HORIZONTAL - SHADING FACTOR* (Shading Coefficient) N (North), NE (North East), E (East), SE (South East), S (South), SW (South West), W (West), NW (North West)										
Latitude	**Shading Proportion**	**Shading Factor**								
Northern Hemisphere		**N**	**NE**	**E**	**SE**	**S**	**SW**	**W**	**NW**	**Average**
Southern Hemisphere		**S**	**SE**	**E**	**NE**	**N**	**NW**	**W**	**SW**	
0º - 9º	D_h=H/1	0.49	0.46	0.49	0.50	0.50	0.52	0.52	0.48	**0.50**
	D_h =H/2	0.44	0.39	0.39	0.40	0.46	0.43	0.41	0.41	**0.42**
	D_h =H/3	0.39	0.34	0.32	0.33	0.39	0.36	0.34	0.35	**0.35**
	D_h =H/4	0.35	0.29	0.27	0.28	0.33	0.31	0.28	0.30	**0.30**
10º - 19º	D_h=H/1	0.47	0.44	0.47	0.51	0.51	0.52	0.49	0.47	**0.48**
	D_h =H/2	0.42	0.38	0.38	0.40	0.43	0.42	0.41	0.41	**0.40**
	D_h =H/3	0.36	0.33	0.31	0.32	0.35	0.35	0.34	0.35	**0.34**
	D_h =H/4	0.32	0.29	0.26	0.27	0.30	0.30	0.30	0.32	**0.29**
20º - 29º	D_h=H/1	0.47	0.44	0.47	0.50	0.51	0.52	0.50	0.46	**0.48**
	D_h =H/2	0.41	0.38	0.37	0.39	0.41	0.41	0.40	0.41	**0.40**
	D_h =H/3	0.36	0.33	0.31	0.32	0.34	0.34	0.34	0.35	**0.33**
	D_h =H/4	0.31	0.28	0.26	0.26	0.29	0.29	0.28	0.31	**0.29**
30º - 39º	D_h=H/1	0.47	0.43	0.46	0.49	0.51	0.51	0.49	0.46	**0.48**
	D_h =H/2	0.41	0.37	0.36	0.38	0.40	0.40	0.39	0.40	**0.39**
	D_h =H/3	0.36	0.32	0.29	0.30	0.33	0.32	0.33	0.35	**0.32**
	D_h =H/4	0.31	0.28	0.25	0.25	0.28	0.27	0.28	0.31	**0.28**
40º - 49º	D_h=H/1	0.46	0.39	0.40	0.43	0.46	0.46	0.45	0.44	**0.44**
	D_h =H/2	0.40	0.34	0.31	0.33	0.36	0.36	0.37	0.39	**0.36**
	D_h =H/3	0.35	0.29	0.25	0.26	0.29	0.29	0.30	0.33	**0.30**
	D_h =H/4	0.31	0.25	0.21	0.21	0.23	0.24	0.26	0.29	**0.25**
50º - 60º	D_h=H/1	0.33	0.30	0.34	0.38	0.40	0.39	0.36	0.32	**0.35**
	D_h =H/2	0.24	0.23	0.24	0.26	0.28	0.26	0.25	0.24	**0.25**
	D_h =H/3	0.18	0.18	0.18	0.19	0.20	0.19	0.19	0.19	**0.19**
	D_h =H/4	0.15	0.14	0.14	0.15	0.16	0.15	0.15	0.15	**0.15**

Table 14: Shading factors for vertical shading devices at different latitudes for each orientation

VERTICAL - SHADING FACTOR* (Shading Coefficient) N (North), NE (North East), E (East), SE (South East), S (South), SW (South West), W (West), NW (North West)										
Latitude	Shading Proportion	Shading Factor								
Northern Hemisphere		N	NE	E	SE	S	SW	W	NW	Average
Southern Hemisphere		S	SE	E	NE	N	NW	W	SW	
0º - 9º	D_v=W/1	0.23	0.23	0.18	0.22	0.23	0.20	0.18	0.21	**0.21**
	D_v=W/2	0.21	0.19	0.15	0.18	0.22	0.17	0.15	0.18	**0.18**
	D_v=W/3	0.19	0.16	0.12	0.15	0.19	0.14	0.12	0.15	**0.15**
	D_v=W/4	0.16	0.14	0.11	0.12	0.16	0.12	0.11	0.13	**0.13**
10º - 19º	D_v=W/1	0.21	0.24	0.20	0.20	0.23	0.18	0.20	0.21	**0.21**
	D_v=W/2	0.19	0.21	0.16	0.16	0.21	0.15	0.17	0.19	**0.18**
	D_v=W/3	0.17	0.18	0.14	0.13	0.17	0.14	0.15	0.16	**0.15**
	D_v=W/4	0.15	0.16	0.12	0.11	0.15	0.12	0.13	0.15	**0.13**
20º - 29º	D_v=W/1	0.22	0.25	0.20	0.21	0.24	0.19	0.20	0.22	**0.21**
	D_v=W/2	0.19	0.21	0.16	0.17	0.20	0.16	0.17	0.19	**0.18**
	D_v=W/3	0.17	0.18	0.13	0.14	0.17	0.14	0.14	0.17	**0.15**
	D_v=W/4	0.15	0.15	0.12	0.11	0.14	0.12	0.12	0.15	**0.13**
30º - 39º	D_v=W/1	0.21	0.26	0.22	0.21	0.24	0.19	0.21	0.23	**0.22**
	D_v=W/2	0.19	0.22	0.17	0.16	0.19	0.16	0.18	0.20	**0.19**
	D_v=W/3	0.17	0.19	0.14	0.13	0.16	0.14	0.15	0.17	**0.16**
	D_v=W/4	0.15	0.16	0.12	0.11	0.14	0.11	0.13	0.15	**0.13**
40º - 49º	D_v=W/1	0.23	0.28	0.24	0.24	0.25	0.23	0.22	0.24	**0.24**
	D_v=W/2	0.20	0.23	0.19	0.17	0.20	0.18	0.19	0.21	**0.20**
	D_v=W/3	0.18	0.19	0.15	0.14	0.16	0.15	0.16	0.17	**0.16**
	D_v=W/4	0.16	0.16	0.13	0.11	0.14	0.13	0.14	0.15	**0.14**
50º - 60º	D_v=W/1	0.26	0.30	0.27	0.27	0.27	0.26	0.27	0.28	**0.27**
	D_v=W/2	0.20	0.22	0.20	0.18	0.20	0.19	0.21	0.21	**0.20**
	D_v=W/3	0.16	0.17	0.16	0.14	0.15	0.15	0.16	0.16	**0.16**
	D_v=W/4	0.13	0.14	0.13	0.11	0.12	0.12	0.13	0.13	**0.13**

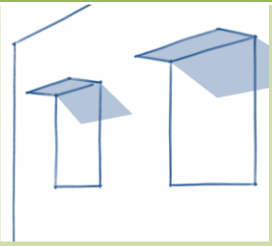
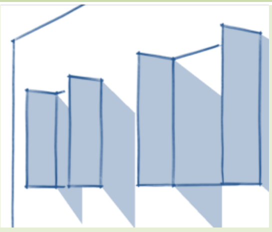
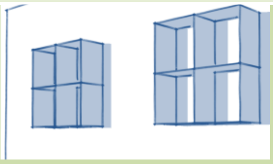
Table 15: Shading factors for combined shading devices (both horizontal and vertical) at different latitudes for each orientation

COMBINED - SHADING FACTOR (Shading Coefficient) N (North), NE (North East), E (East), SE (South East), S (South), SW (South West), W (West), NW (North West)										
Latitude	Shading proportion	Shading Factor								
Northern Hemisphere		N	NE	E	SE	S	SW	W	NW	Average
Southern Hemisphere		S	SE	E	NE	N	NW	W	SW	
0º - 9º	D_h=H/1 & D_v=W/1	0.72	0.69	0.67	0.72	0.74	0.73	0.70	0.70	**0.71**
	D_h=H/2 & D_v=W/2	0.65	0.59	0.54	0.58	0.68	0.60	0.56	0.60	**0.60**
	D_h=H/3 & D_v=W/3	0.58	0.50	0.45	0.48	0.58	0.51	0.47	0.51	**0.51**
	D_h=H/4 & D_v=W/4	0.51	0.43	0.38	0.41	0.50	0.43	0.39	0.44	**0.44**
10º - 19º	D_h=H/1 & D_v=W/1	0.69	0.69	0.67	0.71	0.74	0.70	0.70	0.68	**0.70**
	D_h=H/2 & D_v=W/2	0.60	0.59	0.54	0.56	0.64	0.57	0.59	0.60	**0.59**
	D_h=H/3 & D_v=W/3	0.53	0.51	0.45	0.45	0.53	0.49	0.50	0.52	**0.50**
	D_h=H/4 & D_v=W/4	0.47	0.45	0.39	0.38	0.45	0.42	0.43	0.46	**0.43**
20º - 29º	D_h=H/1 & D_v=W/1	0.69	0.69	0.68	0.71	0.75	0.71	0.70	0.69	**0.70**
	D_h=H/2 & D_v=W/2	0.61	0.59	0.54	0.56	0.62	0.57	0.57	0.60	**0.58**
	D_h=H/3 & D_v=W/3	0.53	0.51	0.44	0.46	0.51	0.48	0.48	0.52	**0.49**
	D_h=H/4 & D_v=W/4	0.47	0.44	0.38	0.38	0.43	0.41	0.41	0.46	**0.42**
30º - 39º	D_h=H/1 & D_v=W/1	0.69	0.69	0.68	0.71	0.75	0.70	0.70	0.69	**0.70**
	D_h=H/2 & D_v=W/2	0.60	0.59	0.53	0.55	0.60	0.56	0.57	0.61	**0.58**
	D_h=H/3 & D_v=W/3	0.53	0.51	0.44	0.44	0.49	0.47	0.48	0.52	**0.48**
	D_h=H/4 & D_v=W/4	0.47	0.44	0.37	0.36	0.41	0.39	0.41	0.46	**0.41**
40º - 49º	D_h=H/1 & D_v=W/1	0.69	0.68	0.64	0.68	0.71	0.69	0.68	0.68	**0.68**
	D_h=H/2 & D_v=W/2	0.61	0.57	0.50	0.50	0.56	0.54	0.56	0.59	**0.55**
	D_h=H/3 & D_v=W/3	0.53	0.49	0.41	0.40	0.45	0.44	0.47	0.51	**0.46**
	D_h=H/4 & D_v=W/4	0.47	0.42	0.35	0.32	0.37	0.37	0.40	0.45	**0.39**
50º - 60º	D_h=H/1 & D_v=W/1	0.62	0.63	0.63	0.66	0.68	0.66	0.65	0.62	**0.64**
	D_h=H/2 & D_v=W/2	0.53	0.51	0.48	0.48	0.51	0.49	0.51	0.53	**0.50**
	D_h=H/3 & D_v=W/3	0.43	0.42	0.38	0.37	0.39	0.38	0.41	0.43	**0.40**
	D_h=H/4 & D_v=W/4	0.36	0.34	0.31	0.29	0.31	0.30	0.34	0.36	**0.33**

Potential Technologies/Strategies

Three basic types of solar shading are used: horizontal, vertical, and combined (egg crate).

Table 16: Typical shading devices

Shading Type	Image	Description
Horizontal shading devices (overhangs):		These are useful for building façades where the sun's rays are at a high angle of incidence, in short, where the sun appears high in the sky. Examples include summer mid-day sun on either the northern or southern façades of a building for higher latitudes, or east and west façades for equatorial latitudes.
Vertical shading devices (fins):		These applications are useful where the sun's rays are at a low angle of incidence (where the sun appears low in the sky). Examples include eastern sun on eastern façades, western sun on western façades, and winter sun on southern or northern façades in high latitudes.
Combined shading devices (egg crate):		"Egg crate" devices are used for conditions where different times of the year warrant different shading needs.
Moveable shading devices – louvres or shutters	 	These devices are used to control sunlight during the day as well as reduce heat losses at night. They are moveable and can be mechanical or manual. They often provide maximum shading as they fully cover the window. These shading devices also protect from inclement weather (hail, wind, or rain) as well as provide privacy and security.

The effectiveness of a shading device varies depending on the location towards the equator (latitude) and the orientation of the window.

Table **17** gives an early indication of the appropriate type of shading device for each orientation.

Table 17: Shading strategies for different orientations at the design stage.

ORIENTATION	EFFECTIVE SHADING
Equator-facing	Fixed Horizontal Device
East	Vertical Device/Louvres (moveable)
Pole-facing	Not required
West	Vertical Device/Louvres (moveable)

Example:

An office building in Istanbul (Turkey) has 1-meter deep horizontal shading on 3 meters high windows in all directions. What is the shading factor for these windows?

The shading factor can be calculated with the built-in calculator in the EDGE software online. If calculating the factor manually, use the following steps:

Step one is to determine the latitude of Istanbul (41 N) from the EDGE online tool design tab, under "Key Assumptions for the Base Case".

Step two is to use the table provided for Horizontal shading (Table 13)and look for the matching latitude category which is "40° to 49°". As the shading is 1/3rd of the window height, "D_v=H/3" should be selected. The average shading factor is 0.30.

Step three is to select external shading measure in the EDGE App and input 0.30 in to the average annual shading factor (AASF) field.

Relationship to Other Measures

External shading reduces the heat gain through solar radiation, therefore a glazing type with a higher solar heat gain coefficient can be selected without a significant negative impact. As external shading cuts the solar heat before it hits the glazed element, it reduces radiative heat gain compared to a treated glass without shading, thus offering better thermal comfort conditions.

Shading reduces heat gain and, therefore, cooling loads. The extent of the savings achieved in cooling energy from shading will be impacted by the efficiency of the cooling system. With a more efficient cooling system, the magnitude of savings from shading alone will be less, even though the combined savings will be greater.

In heating mode, the heating consumption may be increased when external shading is incorporated, due to the reduction of solar heat gains in winter, if shading is not well designed. Well-designed shading cuts out the summer sun but allows in the winter sun which is at a lower altitude.

Assumptions

For the base case, EDGE assumes that no solar shading is present. For the improved case, EDGE assumes a shading factor equivalent to shading devices with a proportion of 1/3 of the height and the width of the window, fitted to all windows. The shading factor is the annual average of eight orientations as shown in the last column of Table 13, Table 14, and Table 15, which is a combination of both vertical and horizontal solar shading.

Compliance Guidance

The information required to demonstrate compliance will depend on the design solution adopted. The simplest design approach is the installation of egg crate shading devices (depth of 1/3 the height and the width) on all windows on all façades. Design teams may prefer to specify the shading device according to the orientation. Table 13, Table 14, Table 15, and Table 16 can be used as guidelines for different sizes and types of shading devices and orientation. Compliance is achieved when the design team has correctly entered the average of the shading factor of all orientations. In the case of external movable shades, the design team can select a Combined Overhang with the greatest projection (W/1 and H/1). In the instance that the building has a more complex shading design, the design team can use specialized software that uses the AASF equation given in the approach section above, to demonstrate that average shading factors have been achieved.

Design Stage	Post-Construction Stage
At the design stage, the following must be used to demonstrate compliance: · All façade elevation drawings highlighting the provision of horizontal and vertical shading devices; and · Window details clearly showing the depth of the shading device and the calculation of the proportion.	At the post-construction stage, the following must be used to demonstrate compliance: · Photographs of the shading devices on all façades; or · As-built façade drawings showing the shading devices that have been installed; or · Update of shading factor calculations when changes have occurred in the design stage.

E03 - REFLECTIVE PAINT/TILES FOR ROOF

Corresponds to HME02, RTE02, OFE02, HSE02, EDE02

Requirement Summary

This measure can be claimed if the solar reflectivity (albedo) of the roof is greater than the local base case as set out in the Key Assumptions for the Base Case in the Design section. EDGE will calculate the impact of any improvement beyond the base case.

Intention

Specifying a reflective finish for the roof can reduce the cooling load in air-conditioned spaces and improve thermal comfort in non-air-conditioned spaces. Due to the reduction in surface temperature, the service life of the finish also improves, and the impact on the urban heat island effect[4] can be reduced.

Approach/Methodologies

EDGE uses the solar reflectivity (albedo) of the roof finish as the indicator of best practice. This is the part of the total incident solar radiation that is reflected back from a surface. Unlike Visible Solar Reflectance, it includes the full solar spectrum. It does not include the effect of emittance which is reflected in a metric such as Solar Reflectance Index (SRI).

The solar reflectivity for a specific roofing material and finish can be acquired from the product manufacturer. It is often indicated in the product data sheet or laboratory test results published on manufacturers' websites. Solar reflectivity is expressed as a fractional value between 0 and 1, or as a percentage.

By subtracting the solar reflectivity from the total level of solar radiation that falls on the roof surface, EDGE calculates the portion of solar radiation that is transferred into the building.

To model more than one roof type, use weighted average values.

To specify a green roof, adjust the solar reflectivity of the roof (use the default of 70% if the actual value is not available), and the insulation of the roof (U-value) to define the green roof condition. Also select the insulation type used in the roof assembly in the Materials tab, under Roof Insulation.

Table 18 provides an indication of the values for different roof finishes, but is meant only as a guide. Manufacturers' published values must be used in the EDGE assessment. If manufacturer data is not available, the EDGE reference values may be used.

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[4] A city's core temperature is often significantly higher than its surrounding area due to the retention of heat from the built environment.

Table 18: Solar reflectivity values for typical roofing materials[5]

Generic Roofing Materials	Solar Reflectivity
Gray EPDM	23%
Gray Asphalt Shingle	22%
Unpainted Cement Tile	25%
White Granular Surface Bitumen	26%
Red Clay Tile	33%
Light Gravel on Built-Up Roof	34%
Aluminum	61%
White-Coated Gravel on Built-Up Roof	65%
White Coating on Metal Roof	67%
White EPDM	69%
White Cement Tile	73%
White Coating - 1 Coat, 8 mils*	80%
PVC White	83%
White Coating - 2 Coats, 20 mils*	85%

* mil is equal to .001 inches or .0254 millimeter

Potential Technologies/Strategies

The key factor in the solar reflectivity of the material or finish is its color. In warm climates a white finish is ideal to maximize reflectivity. If a white finish is not possible then the designer should select a very light color.

[5] Source: Adapted from the LBNL Cool Roofing Materials Database. These values are for reference only and are not for use as substitutes for actual manufacturer data.

Relationship to Other Measures

The impact that the solar reflectivity of the roof has on the energy consumption of a building is dependent upon the insulation levels and the approach used to cool the building, as well as the efficiency of any cooling systems.

The solar reflectivity of the roof finish has a decreased effect on the internal heat gains as the insulation levels are increased. Super-insulated buildings may not benefit significantly from roof finishes with a high solar reflectivity. Higher solar reflectivity values will have no effect on the energy consumption in passively cooled buildings, but may have an impact on virtual energy and, therefore, EDGE results due to occupant comfort.

As the efficiency of the cooling system increases, the solar reflectivity will have a decreasing impact on energy consumption.

If the roof area is a useable area (i.e. for roof activities), then the use of bright white colors is not recommended as they can cause glare and discomfort.

Assumptions

The base case for solar reflectivity may vary in different countries. The base case assumption can be seen in the Design tab under Advanced Settings: Key Assumptions for the Base Case. The typical default value is 30%. The improved case has a default value of 70% which can be adjusted by the user. The actual solar reflectance / reflectivity provided by the manufacturer must be provided for certification.

Compliance Guidance

At both the design and post-construction stage, it is important to ensure that the value obtained for the roof material/finish is the solar reflectivity of the finish rather than an alternative indicator of performance. Solar reflectivity is also referred to as solar reflectance (R). Other values that may be provided by a manufacturer include the solar reflectance index (SRI), visible solar reflectance, the emittance, or gloss units, which are not the same as solar reflectivity.

Design Stage	Post-Construction Stage
At the design stage, the following must be used to demonstrate compliance: · Building design drawings showing the roof material and roof finish; or · Roof specification with solar reflectivity of the roof surface indicated; or · Bill of quantities with the roof finish clearly marked.	At the post-construction stage, the following must be used to demonstrate compliance: · Photographs of the roof materials and finish (where the finish is white, this can be awarded without further evidence); and, either · A product data sheet for the materials and finish (including the solar reflectivity value); or, · Delivery note and purchase documents indicating that the specified roof finish has been delivered to the construction site.

E04 – REFLECTIVE PAINT FOR EXTERNAL WALLS

Corresponds to HME03, RTE03, OFE03, HSE03, EDE03

Requirement Summary

This measure can be claimed if the solar reflectivity (albedo) of the external wall finish is greater than the local base case as set out in the Key Assumptions for the Base Case in the Design section. EDGE will calculate any improvement beyond the base case.

Intention

Specifying a reflective finish for the walls can reduce the cooling load in air-conditioned spaces and improve thermal comfort in non-mechanically cooled spaces. Due to the reduction in surface temperature, the service life of the finish can also be improved and the impact on the urban heat island effect[6] can be reduced.

Approach/Methodologies

EDGE uses the solar reflectivity of the wall finish as the indicator of best practice. This is the part of the total incident solar radiation that is reflected back from a surface. Unlike Visible Solar Reflectance, it includes the full solar spectrum, but does not include the effect of emittance which is reflected in a metric such as Solar Reflectance Index (SRI).

The solar reflectivity for specific wall finishes can be acquired from the product manufacturer. It is often indicated in the product datasheet or laboratory test results published on manufacturers' websites.

[6] A city's core temperature is often significantly higher than its surrounding area due to the retention of heat from the built environment.

Generic Wall Materials	Solar Reflectivity
New concrete	35-45%
New white Portland cement concrete	70-80%
Unpainted concrete masonry unit	40%
White Plaster	90%
White acrylic paint	70%
Light-colored acrylic paint (shades of white)	65%
Medium-colored acrylic paint (green, red, brown)	45%
Dark-colored acrylic paint (dark brown, blue)	25%
Dark blue, Black acrylic paint	15%
Fired clay bricks	17-56%
Red Brick	40%

Table 19 provides an indication of the ranges for different materials but is meant only as a guide. Manufacturers' published values must be used in the EDGE assessment. If manufacturer data is not available, the EDGE reference values may be used as an exception.

Table 19: Solar reflectivity of typical wall finishes[7]

Generic Wall Materials	Solar Reflectivity
New concrete	35-45%
New white Portland cement concrete	70-80%
Unpainted concrete masonry unit	40%
White Plaster	90%
White acrylic paint	70%
Light-colored acrylic paint (shades of white)	65%
Medium-colored acrylic paint (green, red, brown)	45%
Dark-colored acrylic paint (dark brown, blue)	25%
Dark blue, Black acrylic paint	15%
Fired clay bricks	17-56%
Red Brick	40%

Potential Technologies/Strategies

The key consideration of the material used on the façade is its color and potential solar reflectivity.

Relationship to Other Measures

The impact that the solar reflectivity of the walls has upon the energy consumption in a building is dependent on the insulation levels, as well as the approach used to cool the building and the efficiency of any cooling systems.

The solar reflectivity of the wall finish has a decreased effect on the internal heat gains as the insulation levels are increased. Super-insulated buildings may not benefit significantly from wall finishes with a high solar

[7] Ranges are taken from various manufacturers' websites.

reflectivity. Higher solar reflectivity values will have no effect on the energy consumption in passively cooled buildings, but may have an impact on the EDGE rating due to occupant comfort.

As the efficiency of the cooling systems increases, the solar reflectivity will have a decreasing impact on reducing the energy consumption.

A highly reflective surface might cause glare and should be taken into consideration by the design team.

Assumptions

The base case for solar reflectivity may vary in different countries. The base case assumption can be seen in the Design tab under Advanced Settings: Key Assumptions for the Base Case. The typical default value is 30%. The improved case has a default value of 70% which can be adjusted by the user. The actual solar reflectance / reflectivity provided by the manufacturer must be provided for certification.

Compliance Guidance

At both the design and post-construction stage it is important to ensure that the value obtained for the wall material/finish is the solar reflectivity of the finish rather than an alternative indicator of performance. Other values that may be provided by a manufacturer include the solar reflectance index (SRI), visible solar reflectance, the emittance or gloss units, which are not the same as solar reflectivity.

Design Stage	Post-Construction Stage
At the design stage, the following must be used to demonstrate compliance: ▪ Building design drawings showing the wall finish; or ▪ Wall specification with solar reflectivity of the wall's surface indicated; or ▪ Bill of quantities with the wall finish clearly marked.	At the post-construction stage, the following must be used to demonstrate compliance: ▪ Photographs of the wall materials and finish (where the finish is white, this can be awarded without further evidence); and, either ▪ A product data sheet for the wall finish (including the solar reflectivity value); or ▪ A delivery note and purchase documents indicating that the specified wall finish has been delivered to the construction site.

E05* – INSULATION OF ROOF

Corresponds to HME05, HTE03, RTE05, OFE05, HSE05, EDE05

Requirement Summary

This measure refers to the U-value or thermal conductivity of materials as the indicator of performance, in which the use of insulation improves the U-value. The user must select the measure for 'Insulation of the Roof' in the Energy tab in all cases except when the measure is not marked with an asterisk, or when the project U-value is better than the baseline and a project chooses not to take credit for it (an auditor must verify this). The U-value must be entered following the guidelines in the Approach/Methodologies section. Note that the measure for 'Roof insulation' must also be selected in the Materials tab, and the actual insulation type and thickness entered.

Savings from the measure can be claimed if the U-value of the roof is lower than the base case U-value listed in the Key Assumptions for the Base Case in the Design section.

Intention

Insulation is used to prevent heat transmission from the external environment to the internal space (for warm climates) and from the internal space to the external environment (for cold climates). Insulation aids in the reduction of heat transmission by conduction[8], so more insulation implies a lower U-value and better performance. A well-insulated building has lower cooling and/or heating energy requirements.

Please note that many modern insulating materials, such as certain foam-based insulations, as well as air cavities that improve the sustainability and energy efficiency of buildings also spread fire more easily compared to traditional materials such as concrete and wood. The project team is encouraged to take proper fire safety precautions in the selection of these materials and the associated design details such as fire stops.

Approach/Methodologies

This measure uses U-value, which is defined as the quantity of heat that flows through a unit area in unit time, per unit difference in temperature; it is expressed in Watts per square meter Kelvin (W/m^2K). U-value is an indication of how much thermal energy (heat) is transmitted through a material (thermal transmittance). The U-value, which is the performance indicator of this measure, is the reciprocal of the total thermal resistance[9] ($1/\sum R$) of the roof, which is calculated from the individual thermal resistance of each component/layer of the roof.

If the default improved case is used, the design team must demonstrate that the U-value of the roof does not exceed the U-value assumed by EDGE (see assumptions below). This can be obtained by the manufacturer or

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[8] Conduction is the process by which thermal energy moves within an object or between connected objects.

[9] Thermal resistance is a measure of how much heat loss is reduced through the given thickness of a material. Thermal resistance is expressed as the R, which is measured in square meters Kelvin per Watt (m^2K/W).

by the "simple method" calculation, explained as follows. If a different U-value for the roof is used, then it must be calculated with the following formula or in accordance with the "combined method"[10] given in ISO 6946. For multiple roof types with different U-values, use an area-weighted average.

Simple method of calculating the U-value:

$$U - Value \ = \frac{1}{Rsi+Rso+R1+R2+R3\ etc}$$

Where: *Rsi* = Resistance of the air layer on the inner side of the roof (add constant of air)

Rso = Resistance of the air layer on the external side of the roof

R1,2 etc. = Resistance of each material layer within the roof

The resistance of a roof material is derived by the following formula: $R = \frac{d}{\lambda}$

Where: d = Thickness of the layer of material (m)

λ = Thermal conductivity[11] in W/m K

As seen in the formula above, the insulating capacity is a direct function of the thickness of the material. Table 20 demonstrates how to achieve a U-value of 0.45W/m² K, with the thickness of certain insulation materials indicated. The actual thickness required will depend on many other factors, including the fixing method, roof construction and position of the insulation within the material layers.

[10] Several websites give worked examples for the calculation of the U-value according to the "combined method:"

1. Conventions for U-value calculations, Brian Anderson, BRE, 2006. http://www.bre.co.uk/filelibrary/pdf/rpts/BR_443_(2006_Edition).pdf
2. Worked examples of U-value calculations using the combined method, The Scottish Government, 2009 - http://www.scotland.gov.uk/Resource/Doc/217736/0088293.pdf
3. Determining U-values for real building elements, CIBSE - http://www.cibsejournal.com/cpd/2011-06/

[11] Thermal conductivity is a standardized measure of how easily heat flows through any specific material, independent of material thickness. It is measured in Watts per meter Kelvin (W/m K), and is often expressed as the "K Value" or "λ".

Table 20: Thickness of insulation required to achieve a U-value of 0.45 W/m² K

Insulation Type	Thickness (mm) Approximate values to achieve a U-value of 0.45W/m² K	Thermal Conductivity (W/m K)
Vacuum Insulated Panels	10 - 20mm	0.008
Polyurethane (PU)	40 - 80mm	0.020 - 0.038
Polyisocyanurate (PIR)	40 - 60mm	0.022 - 0.028
Phenolic Foam (PF)	40 - 55mm	0.020 - 0.025
Expanded Polystyrene (EPS)	60 - 95mm	0.030 - 0.045
Extruded Polystyrene (XPS)	50 - 80mm	0.025 - 0.037
Wool and Fiberglass	60 - 130mm	0.030 - 0.061

Source: Insulation Materials Chart, Energy Savings Trust, 2004.

EDGE provides a built-in calculator for calculating the U-value of a roof with multiple layers of materials layered on top of each other. For more complex assemblies, for example, if the materials are not in continuous layers or metal penetrations punctuate the roof, dedicated U-value calculation software or energy modelling software can also be used.

Potential Technologies/Strategies

Insulating the roof is potentially the most cost-effective way to reduce the energy used for heating a building. Therefore, in cold or temperate climates there is a strong case for maximizing the insulation before designing the heating ventilation and air conditioning equipment. In hot climates insulating the roof can reduce heat gain, but the effect is relatively minor.

Different types of insulation are available, and the appropriate type will depend on the application as well as cost and availability. Insulation types can be grouped into four main categories, as shown in Table 21.

Table 21. Insulation types and typical conductivity range

Insulation Type	Description	Typical Conductivity Range *(λ - K Value)*
Matting, Blanket, or Quilt Insulation	This type of insulation is sold in rolls of different thicknesses and is typically made from mineral wool (fiber made from glass or rock). Some common uses include insulating empty lofts, stud walls, and under suspended timber floors. Other materials such as sheep's wool are also available.	0.034 – 0.044
Loose-fill Material	Loose-fill material, made of cork granules, vermiculite, mineral wool, or cellulose fiber is usually poured between the joists to insulate lofts. It is ideal for loft spaces with awkward corners or obstructions, or if the joists are irregularly spaced.	0.035 – 0.055
Blown Insulation	Blown insulation is made from cellulose fibers or mineral wool. Spray foam insulation is made from Polyurethane (PUR). Blown insulation should only be installed by professionals, who use special equipment to blow the material into a specific, sectioned-off area, to the required depth. The material may remain loose if used for loft insulation, but can also bond to a surface (and itself) for insulating stud walls and other spaces.	0.023 – 0.046
Rigid Insulation Boards	Rigid insulation boards are mostly made from foamed plastic such as polystyrene, polyurethane (PUR), or polyisocyanurate (PIR), which can be used to insulate walls, floors, and ceilings. PUR and PIR board are among the best insulation materials commonly used, and so are useful where space is limited. Rigid board must be cut to size, so fitting is often a skilled job.	0.02 – 0.081

The range of thermal conductivity can be used by auditors and reviewers to check for reasonableness of the project team's claims about insulation properties. It can also be used as a substitute in the rare case when manufacturer data is not available.

Relationship to Other Measures

Selecting this measure will show an increase in the environmental impact in the materials section due to the addition of insulation material (reflected as a negative percent improvement).

However, by increasing the level of insulation the heating and/or cooling loads will be reduced. Increasing the levels of insulation could therefore reduce the cost and environmental impact of the heating and cooling plant, leading to energy savings that more than compensate for the negative impacts in the materials section.

Assumptions

The base case insulation assumed in the roof varies by building type and location. The base case U-value can be seen in the Advanced Settings: Key Assumptions for the Base Case in the Design tab. The default value for the improved case is that the actual U-value is better (lower) than the base case listed in the Key Assumptions.

Compliance Guidance

To claim savings from this measure, it is necessary to demonstrate that the U-value of the complete roof specification is better (lower) than the base case as listed in the Key Assumptions for the Base Case in the Design section. If the EDGE default for the improved case U-value is used, then it is only necessary to demonstrate that insulation has been or will be installed, and that its U-value does not exceed the default improved case value. The U-value is the reciprocal of the sum of the R-values for each component of the roof structure.

If a U-value has been entered that exceeds the improved case, then it is necessary to confirm that the U-value was calculated in accordance with the “combined method” given in ISO 6946 as shown in the Approach/Methodologies above.

Design Stage	Post-Construction Stage
At the design stage, the following evidence must be used to demonstrate compliance: · A roof construction detail drawing showing the insulation material. Ideally, the roof detail drawing should be annotated with the U-value of the roof; and · Calculations of U-value either using the formula provided or U-value calculators; or · Manufacturer’s data sheet of specified insulation material for the roof.	Since the insulation material will not be visible at the post-construction stage, it must be demonstrated that the insulation material specified at the design stage was delivered to the site. The following must be used to demonstrate compliance: · Photographs of the roof construction at a point when the insulation material was visible; and · Delivery note confirming that the insulation material was delivered to the site; and · Updated calculations for the U-value if the thickness and type of insulation have changed from the original design.

E06* – INSULATION OF EXTERNAL WALLS

Corresponds to HME06, HTE04, RTE06, OFE06, HSE06, EDE06

Requirement Summary

This measure refers to U-value as the indicator of performance, in which the use of insulation improves the U-value. The measure can be claimed if the U-value of the external walls is lower than the base case U-value listed in the Key Assumptions for the Base Case in the Design section. The user must select the measure for 'Insulation of the External Walls' in the Energy tab in all cases except when the measure is not marked with an asterisk, or when the project U-value is better than the baseline and a project chooses not to take credit for it (an auditor must verify this).

The actual U-value of the wall should be entered in the software by selecting the measure for 'Insulation of External Walls' in the Energy tab. For multiple exterior wall types with different U-values, use an area-weighted average. Note that the measure for 'Wall Insulation' should also be selected in the Materials tab, and the actual insulation type and thickness entered.

Intention

Insulation is used to prevent heat transmission from the external environment to the internal space (for warm climates) and from the internal space to the external environment (for cold climates). Insulation aids in the reduction of heat transmission by conduction[12], so more insulation implies a lower U-value and better performance. A well-insulated building has lower cooling and/or heating energy requirements.

Please note that many modern insulating materials, such as certain foam-based insulations, as well as air cavities that improve the sustainability and energy efficiency of buildings also spread fire more easily than traditional materials such as concrete and wood. The project team is encouraged to take proper fire safety precautions in the selection of these materials and the associated design details such as fire stops.

Approach/Methodologies

This measure uses U-value, which is defined as the quantity of heat that flows through unit area in unit time, per unit difference in temperature; it is expressed in Watts per square meter Kelvin (W/m^2K). U-value is an indication of how much thermal energy (heat) is transmitted through a material (thermal transmittance). The U-value, which is the performance indicator of this measure, is the reciprocal of the total thermal resistance[13] ($1/\sum R$) of the external walls, which is calculated from the individual thermal resistance of each component/layer of each external wall.

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[12] Conduction is the process by which thermal energy moves within an object or between connected objects.

[13] Thermal resistance is a measure of how much heat loss is reduced through a given thickness of a material. Thermal resistance is expressed as the R, which is measured in square meters Kelvin per Watt (m^2K/W).

If the default improved case is used (as shown in EDGE as the top insulation material in the dropdown), the design team must demonstrate that the U-value of the external walls does not exceed the U-value assumed by EDGE. This can be obtained by the manufacturer or by the “simple method” calculation, which is explained as follows. If a different U-value for the external walls is used, then it must be calculated with the following formula or in accordance with the “combined method”[14] given in ISO 6946.

Simple method of calculating the U-value:

$$U-Value = \frac{1}{Rsi+Rso+R1+R2+R3\ etc}$$

Where: *Rsi* = Resistance of air layer on the inner side of the external wall (add constant of air)

Rso = Resistance of air layer on the external side of the external wall

R1, 2 etc. = Resistance of each layer material within the external wall

The resistance of a wall material is derived by the following formula: $R = \frac{d}{\lambda}$

Where: d = Thickness of the layer of material (m)

λ = Thermal conductivity[15] in W/m K

As seen in the formula above, the insulating capacity is a direct function of the thickness of the material. Table 22 demonstrates how to achieve a U-value of 0.45W/m² K for a certain thickness. The actual thickness required will depend on many other factors, including the fixing method, wall construction, and the position of the insulation within the material layers.

[14] Several websites give worked examples for the calculation of the U-value according to the “combined method:”

4. Conventions for U-value calculations, Brian Anderson, BRE, 2006. http://www.bre.co.uk/filelibrary/pdf/rpts/BR_443_(2006_Edition).pdf
5. Worked examples of U-value calculations using the combined method, The Scottish Government, 2009 - http://www.scotland.gov.uk/Resource/Doc/217736/0088293.pdf
6. Determining U-values for real building elements, CIBSE - http://www.cibsejournal.com/cpd/2011-06/

[15] Thermal conductivity is a standardized measure of how easily heat flows through any specific material, independent of material thickness. It is measured in Watts per meter Kelvin (W/m K), and is often expressed as the “K Value” or “λ”.

Table 22: Thickness of insulation required to achieve a U-value of 0.45 W/m² K[16]

Insulation Type	Thickness (mm) Approximate values to achieve a U-value of 0.45W/m² K	Thermal Conductivity (W/m K)
Vacuum Insulated Panels	10 - 20mm	0.008
Polyurethane (PU)	40 - 80mm	0.020 - 0.038
Polyisocyanurate (PIR)	40 - 60mm	0.022 - 0.028
Phenolic Foam (PF)	40 - 55mm	0.020 - 0.025
Expanded Polystyrene (EPS)	60 - 95mm	0.030 - 0.045
Extruded Polystyrene (XPS)	50 - 80mm	0.025 - 0.037
Wool and Fiber	60 - 130mm	0.030 - 0.061

EDGE provides a built-in calculator for calculating the U-value of a wall with multiple layers of materials next to each other. For more complex assemblies, for example, if the materials are not in continuous layers or metal penetrations punctuate the wall, dedicated U-value calculation software or energy modelling software can also be used.

Potential Technologies/Strategies

Insulating the external walls is potentially the most cost-effective way to reduce the energy used for heating a building. Therefore, in cold or temperate climates a strong case can be made for maximizing the insulation before designing the heating ventilation and air conditioning equipment. In hot climates insulating the wall can reduce heat gain, but the effect is relatively minor.

[16] Source: Insulation Materials Chart, Energy Savings Trust, 2004

Different types of insulation are available, and the appropriate type will depend on the application as well as cost and availability. Insulation types can be grouped into four main categories, as shown in Table 23:

Table 23. Insulation types and typical conductivity range

Insulation Type	Description	Typical Conductivity Range (*λ - K Value)*
Matting, Blanket, or Quilt Insulation	This type of insulation is sold in rolls of different thicknesses and is typically made from mineral wool (fiber made from glass or rock). Some common uses include insulating empty lofts, stud walls, and under suspended timber floors. Other materials such as sheep's wool are also available.	0.034 – 0.044
Loose-fill Material	Loose-fill material, made of cork granules, vermiculite, mineral wool, or cellulose fiber is usually poured between the joists to insulate lofts. It is ideal for loft spaces with awkward corners or obstructions, or if the joists are irregularly spaced.	0.035 – 0.055
Blown Insulation	Blown insulation is made from cellulose fibers or mineral wool. Spray foam insulation is made from Polyurethane (PUR), and should only be installed by professionals, who use special equipment to blow the material into a specific, sectioned-off area, to the required depth. The material may remain loose if used for loft insulation, but can also bond to a surface (and itself) for insulating stud walls and other spaces.	0.023 – 0.046
Rigid Insulation Boards	Rigid insulation boards are mostly made from foamed plastic such as polystyrene, polyurethane (PUR), or polyisocyanurate (PIR), which can be used to insulate walls, floors, and ceilings. PUR and PIR board are among the best insulation materials commonly used, and so are useful where space is limited. Rigid board has to be cut to size, so fitting is often a skilled job.	0.02 – 0.081

Auditors and reviewers can use the range of thermal conductivity to check for reasonableness of the project team's claims about insulation properties. The range can also be applied as a substitute in the rare case when manufacturer data is not available.

Relationship to Other Measures

Selecting this measure will show an increase in the environmental impact in the materials section due to the addition of insulation material (reflected as a negative percentage impact).

By increasing the level of insulation, the heating and/or cooling loads will be reduced. Increasing the levels of insulation could therefore reduce the cost and environmental impact of the heating and cooling plant.

If this measure is not selected, which assigns the Wall a U-value, a U-value will be assigned to the wall via the selection of the Exterior Wall Material. Changing the wall material will change the heat transfer through the wall which will impact the building's energy use.

Assumptions

The base case insulation assumed in the roof varies by building type and location. The base case U-value can be seen in the Advanced Settings: Key Assumptions for the Base Case in the Design tab. The default value for the improved case is that the actual U-value is better (lower) than the base case listed in the Key Assumptions.

Compliance Guidance

To claim this measure, it is necessary to demonstrate that the U-value of the complete external walls specification is better (lower) than the base case as listed in the Key Assumptions for the Base Case in the Design section. If the EDGE default for the improved case U-value is used, then it is only necessary to demonstrate that insulation has been or will be installed, and that the U-value of the External Walls does not exceed the base case.

If a user-input U-value exceeds the default improved case value, then it is necessary to confirm that the U-value has been calculated in accordance with the "simple" or "combined" method as shown in the Approach/Methodologies above.

Design Stage	Post-Construction Stage
At the design stage, the following must be used to demonstrate compliance: · External walls construction detail drawing showing the insulation material. Ideally the external walls detail drawing should be annotated with the U-value of the external walls; and · Calculations of U-value either using the formula or U-value calculators; or · Manufacturer's data sheet of specified insulation material for the external walls.	Since the insulation material will not be visible at the post-construction stage, it must be demonstrated that the insulation material specified at the design stage was delivered to the site. The following must be used to demonstrate compliance: · Photographs of the external wall construction at a point when the insulation material was visible; and · Delivery note confirming that the insulation material was delivered to the site; and · Updated calculations for U-value if the thickness and type of insulations have changed from the original design.

E07 – LOW-E COATED GLASS

Corresponds to HME07, HTE05, RTE07, OFE07, HSE07, EDE07

Requirement Summary

This measure can be claimed if Low Emissivity (Low-E) coated glazing is used.

Even if the U-value of the actual window in the building is worse (higher) than the base case value, the measure must be selected, and the U-value entered when the measure is required (marked with an asterisk). For example, this could happen in countries where double glazing is the norm for office buildings, making the base case values quite good. The same principle is applicable to SHGC, i.e. if the SHGC is different from the base case assumption, the measure must be selected and the actual SHGC must be entered.

Intention

The addition of a Low-E coating to glazing reduces the transference of heat from one side to the other by reflecting thermal energy. Low-E coatings are microscopically thin metal or metallic oxide layers that are deposited on a glass surface to help keep heat on the same side of the glass from which it originated. In warm climates the intention is to reduce heat gain, and in cold climates the intention is to reflect interior warmth back indoors.

Approach/Methodologies

Low-E coating reduces the Solar Heat Gain Coefficient (SHGC) and thermal conductivity (U-Value) of the glazing. These concepts are explained as follows:

The SHGC is expressed as a number between 0 and 1 and indicates the fraction of incident solar radiation admitted through a window, both directly transmitted and absorbed and subsequently released inward[17]. A solar heat gain coefficient indicates lesser solar heat transmitted.

All Low-E glass will have a reduced U-Value compared to plain glass; however, the product's solar heat gain performance determines its appropriateness for a particular climate. For warm climates, Low-E glass with a low SHGC helps reduce unwanted solar gains but in cold climates, Low-E glazing that has minimal impact on SHGC is more desirable.

In both warm and cold climates, the lower U-Value of Low-E glazing is an advantage. Manufacturers often provide separate U-Values for summer and winter (or the heating and cooling seasons). A simple approach is to calculate the average of these two values. If an alternative approach is used to calculate the seasonal average, then this must be justified. For example, an acceptable justification is if the building is in an area that lacks a

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[17] http://www.efficientwindows.org/shgc.php (accessed 3/28/18)

heating season. In cases where multiple glass types are used, a weighted average must be applied, which can be calculated using the built-in calculator in EDGE.

Potential Technologies/Strategies

Low-E coating is applied to different sides of the glazing depending on the climate. In single-pane windows, the coating may be applied inside or outside depending on the coating. For double pane windows, the coating is usually applied on the outer surface of the inner pane in warm climates to allow useful solar radiation to pass through to passively heat the interior, and to reduce the ability for infrared radiation to reflect back out. In warm climates, the coating is usually applied on the inner surface of the outer pane, as this helps to reflect the solar radiation back outside before it enters the air cavity.

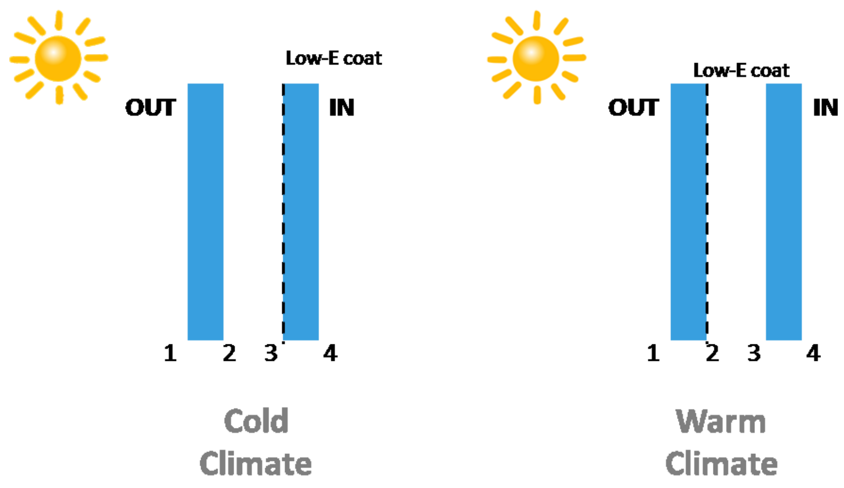


Figure 8. Recommended position of the low-e coating for double-pane glass

Two types of Low-E coating are available: hard coat and soft coat. Only hard coat (pyrolytic coating) should be used in single-glazed units as it is more durable than soft coat (sputter coating).

- **Hard Coat Low-E:** Hard coat Low-E, or pyrolytic coating, is a coating applied at high temperatures and is sprayed onto the glass surface during the float glass process. The coating process, known as Chemical Vapor Deposition (CVD), uses a variety of chemicals including silicon, silicon oxides, titanium dioxide, aluminum, tungsten, and many others. The vapor is directed at the glass surface and forms a covalent bond with the glass, so the result is hard wearing.
- **Soft Coat Low-E:** Soft coat Low-E, or sputter coating, is applied in multiple layers of optically transparent silver sandwiched between layers of metal oxide in a vacuum chamber. This process provides the highest level of performance and a nearly invisible coating. However, it is highly susceptible to damage from handling (recommended in double glazing units).

Table **24** shows a range of U-Values and SHGC values for different types of glazing, and provides guidance for the selection of glazing. However, this data varies from manufacturer to manufacturer; for certification purposes actual values from the manufacturer must be provided. In addition, many manufacturers' literature indicates the Solar Coefficient (SC) instead of the SHGC, with the conversion equation as follows:

$$SHGC = SC\ X\ 0.87$$

Table 24: Approximate SHGC and U-values for different glazing types

Glass Configuration					Approximate SHGC	Approximate U-value [W/m² K]
Type of Glass	**Performance**	**Thickness (mm)**	**Color**	**Coated**		
Single glass	Medium solar control	6 mm (Double)	Gold	Hard (Pyrolytic)	0.45	2.69-2.82
	Good solar control	6 mm	Blue / Green	Soft (sputtered)	0.36 – 0.45	3.01 -3.83
				Hard (Pyrolytic)	0.33 - 0.41	2.84 – 3.68
		8 mm	Blue / Green	Soft (sputtered)	0.32	2.99 – 3.79
				Hard (Pyrolytic)	0.30 - 0.37	2.82 – 3.65
		6 mm	Bronze	Soft (sputtered)	0.45	3.01 -3.83
		6 mm	Grey	Soft (sputtered)	0.41	3.01 -3.83
				Hard (Pyrolytic)	0.36	2.84 – 3.68
		8 mm	Grey	Hard (Pyrolytic)	0.32	2.82 – 3.65
		6 mm	Clear	Hard (Pyrolytic)	0.52	2.83 -3.68
		8 mm	Clear	Hard (Pyrolytic)	0.51	2.81 -3.65

Relationship to Other Measures

Applying a Low-E coating either reduces the heat load by reducing the heat loss through the glazing, or reduces the cooling load by reducing the solar heat gain. As with other measures which relate to the improvement of the building fabric, addressing and optimizing performance is cheaper to do before sizing/selecting heating, ventilation, and the air-conditioning plant.

Care must be taken in cold climates, because as the U-Value is reduced, the SHGC is reduced even further for many coatings. Therefore, although a Low-E glass with a very low U-Value may appear to be a good choice, the performance may actually be worse if it has low SHGC that reduces heat gain from the sun and increases heating requirements. In those cases, a window with low U-value but with a higher solar heat gain coefficient (SHGC) is the right selection.

Note that if the Higher Performance Glass measure is also claimed, then this measure will not contribute to the calculation of savings.

Assumptions

The base case values for the U-Value and SHGC of the window are included in the Key Assumptions for the Base Case in the Design section. These can vary based on several factors such as location and building type. The default values for the improved case assumptions for a window with Low-E coated glass are a U-value of 3 W/m² K and an SHGC of 0.45.

Compliance Guidance

When the project has multiple types of glazing with multiple U-values and SHGC, a weighted average U-value and SHGC must be entered in the user entry fields.

The following information must be provided to show compliance at the design and post-construction stages:

Design Stage	Post-Construction Stage
At the design stage, the following must be used to demonstrate compliance: · Manufacturer's data sheets showing the seasonal average U-Value for the window (including glass and frame) and the solar heat gain coefficient (SHGC) of the glass and frame; and · A list of different types of window included in the design (window schedule).	At the post-construction stage, the following must be used to demonstrate compliance: · Photographs of the glazing units installed; · Purchase receipts and delivery notes for the glazing; and · Manufacturer's data sheets showing the seasonal average U-Value for the window (including glass and frame) and the solar heat gain coefficient (SHGC) of the glass and frame.

E08 – HIGH THERMAL PERFORMANCE GLASS

Corresponds to HME08, HTE06, OFE08, HSE08

Requirement Summary

This measure can be claimed if the glazing is multi-paned (double or triple) and has a superior thermal performance.

Even if the U-value of the actual window in the building is worse (higher) than the base case value, the measure must be selected and the U-value entered when the measure is required (marked with an asterisk). For example, this could happen in countries where double glazing is the norm for office buildings, making the base case values quite good. The same principle is applicable to SHGC, i.e. if the SHGC is different from the base case assumption, the measure must be selected and the actual SHGC must be entered.

Intention

By selecting double or triple glazing, which has an improved thermal performance as well as a coating (tinted glass or Low-E) the heat transfer is reduced further than with low-E coating alone, and an even lower SHGC can be achieved.

Approach/Methodologies

Double or triple glazing or coating reduces the Solar Heat Gain Coefficient (SHGC) and thermal conductivity (U-Value) of the glazing. These concepts are explained as follows:

The SHGC is expressed as a number between 0 and 1 and indicates the fraction of incident solar radiation admitted through a window, both directly transmitted and absorbed and subsequently released inward[18]. A solar heat gain coefficient indicates lesser solar heat transmitted.

All Low-E glass will have a reduced U-Value compared to plain glass; however, the product's solar heat gain performance determines its appropriateness for a given climate. For warm climates, Low-E glass with a low SHGC helps reduce unwanted solar gains but in cold climates, Low-E glazing that has minimal impact on solar gains is required.

In both warm and cold climates, the lower U-Value of Low-E glazing is an advantage. Manufacturers often provide separate U-Values for summer and winter (or the heating and cooling seasons). A simple approach is to calculate the average of these two values. If an alternative approach is used to calculate the seasonal average, then this must be justified. For example, an acceptable justification is that the building is in an area without a heating season.

[18] http://www.efficientwindows.org/shgc.php (accessed 3/28/18)

Potential Technologies/Strategies

Table 25 shows a range of U-values and SHGC values for different types of glazing. It is provided as guidance for the selection of glazing. However, this data varies from manufacturer to manufacturer. For certification purposes actual values from the manufacturer must be provided. In addition, many manufacturers' literature indicates the Solar Coefficient (SC) instead of the SHGC. This can be converted using the following equation:

$$SHGC = SC\ X\ 0.87$$

Table 25: Approximate SHGC and U-values for different glazing types

Glass Configuration					Approximate SHGC	Approximate U-value [W/m² K]
Type of Glass	**Performance**	**Thickness (mm)**	**Color**	**Coated**		
Single glass	Medium solar control	6 mm (Double)	Gold	Hard (Pyrolytic)	0.45	2.69-2.82
	Good solar control	6 mm	Blue / Green	Soft (sputtered)	0.36 – 0.45	3.01 -3.83
				Hard (Pyrolytic)	0.33 - 0.41	2.84 – 3.68
		8 mm	Blue / Green	Soft (sputtered)	0.32	2.99 – 3.79
				Hard (Pyrolytic)	0.30 - 0.37	2.82 – 3.65
		6 mm	Bronze	Soft (sputtered)	0.45	3.01 -3.83
		6 mm	Grey	Soft (sputtered)	0.41	3.01 -3.83
				Hard (Pyrolytic)	0.36	2.84 – 3.68
		8 mm	Grey	Hard (Pyrolytic)	0.32	2.82 – 3.65
		6 mm	Clear	Hard (Pyrolytic)	0.52	2.83 -3.68
		8 mm	Clear	Hard (Pyrolytic)	0.51	2.81 -3.65

Relationship to Other Measures

High performance glass either reduces the heat load by reducing the heat loss through the glazing, or reduces the cooling load by reducing the solar heat gain. As with other measures which relate to the improvement of the building fabric, addressing and optimizing performance is cheaper to do before sizing/selecting heating, ventilation, and the air-conditioning plant. If the Higher Performance Glass measure is claimed, then this measure will not contribute to the calculation of savings.

Particular care must be taken in cold climates; although a Low-E glass with a very low U-value appears to be a good choice, it may actually have worse performance if it also has low SHGC solar heat gain that blocks the warmth of the sun and increases heating requirements. In those cases, a double or triple layer glass with a high solar heat gain coefficient is the right selection.

Assumptions

The Key Assumptions for the Base Case in the Design section show the base case values for the U-value and SHGC of the window. The default values for the improved case for high thermal performance windows are a U-value of 1.95 W/m² K and an SHGC of 0.28.

Compliance Guidance

When a project has multiple types of glazing with multiple U-values and SHGC, a weighted average U-value and SHGC can be entered into the user entry fields.

The following information must be provided to show compliance at the design and post-construction stages:

Design Stage	Post-Construction Stage
At the design stage, the following must be used to demonstrate compliance: · Manufacturer's data sheets showing the seasonal average U-value for the window (including glass and frame) and the solar heat gain coefficient (SHGC) of the glass and frame; and · A list of different types of windows included in the design (window schedule).	At the post-construction stage, the following must be used to demonstrate compliance: · Photographs of the glazing units installed; · Purchase receipts and delivery notes for the glazing; and · Manufacturer's data sheets showing the seasonal average U-value for the glazing (including glass and frame) and the solar heat gain coefficient (SHGC) of the glass and frame.

E09 – NATURAL VENTILATION

Corresponds to HME09, HTE07, HTE08, RTE08, OFE09, HSE09, HSE10, HSE11, EDE08, EDE09

Requirement Summary

This measure can be claimed when two conditions are met.

1. Room geometry conditions must be met. These include the 'room depth to ceiling height ratio' and the 'minimum area of opening.'
2. If the rooms are air-conditioned, the air-conditioning system in the rooms must be provided with an auto-shut off control that switches the air-conditioning off while the room is being naturally ventilated.

The methodology for the calculation is explained in the Potential Technologies and Strategies section, which also shows the minimum required ventilation conditions and an example of auto-shut off controls.

Table 26 shows the spaces that must be naturally ventilated for each building type to claim the natural ventilation measure. Each row in the table represents a separate measure in the software.

Table 26: Areas to be Naturally Ventilated, by Building Type

Building Type	Spaces that must have natural ventilation
Homes	Bedrooms, Living Room, Kitchen
Hospitality	Corridors
	Guest Rooms (with auto controls)
Retail	Corridors, Atrium, and Common Areas
Offices	Offices, Corridors and Lobby
Hospitals	Corridors
	Lobby, Waiting, and Consultation Areas
	Patient Rooms
Education	Corridors
	Classrooms

For multiple rooms of one type, the condition must be met by 90% of the rooms of that type in the building e.g. rooms of a hotel.

Intention

A well-designed natural ventilation strategy can improve occupant comfort by providing both access to fresh air as well as reducing the temperature. This results in a reduction of the cooling load, which lowers initial capital and maintenance costs.

Approach/Methodologies

The key factors in deciding the ventilation strategy are room size (depth, width and height), and the number and location of openings.

Both the 'room depth to ceiling height ratio' and the 'minimum area of opening' must be calculated using the built-in calculator in EDGE. Each relevant space type for a project must be entered on a separate row in the calculator, to ensure adequate natural ventilation for all the required spaces in the building. All space types required for a building type must pass in the calculator in order to claim the measure.

To evaluate whether the openings on a wall qualify for natural ventilation, take the window-to-wall ratio for that particular wall. The window area must be at least 10% of the wall area to be counted as an opening for natural ventilation. Openings less than 10% of the wall must not be considered for natural ventilation (although it will still count towards the WWR calculation).

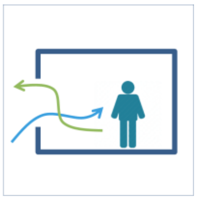
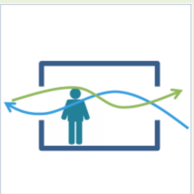
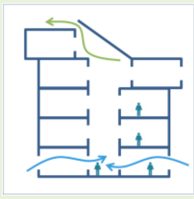
Potential Technologies/Strategies

Figure 9. Auto shut-off control for air-conditioning based on natural ventilation

EDGE uses cross-flow ventilation, where fresh air is drawn from outside into the occupied space and the exhaust air is delivered at a different location, as explained in Table 27. This type of ventilation is used for the improved case as it is most effective if the external air temperature is neither too hot nor too cold (temperate climates). As EDGE takes into account the external temperature, the software can test the ventilation's potential effectiveness. If EDGE predicts significant savings, then a suitable strategy should be considered.

Two basic approaches are most often implemented in the design of cross ventilation: single-sided and two-sided. Two-sided ventilation is used to ventilate single spaces (which have openings on both windward and leeward sides) and double-banked rooms that rely on openings in corridors between rooms. Single-sided ventilation is used where two-sided ventilation is not possible, but the room depth that can be ventilated in this way is much lower.

Table 27: Types of natural ventilation

Type	Image	Description
Single-sided Ventilation		Single-sided ventilation relies on the pressure differences between different openings within a single space. It is more predictable and effective than if there is only a single opening, and can therefore be used for spaces with greater depth. For spaces that only have a single opening the ventilation is driven by turbulence. This turbulence creates a pumping action on the single opening, causing small inflows and outflows. As this is a less predictable method, the room depth for single opening, single-sided ventilation is reduced.
Cross-ventilation - Single Spaces		Cross ventilation of single spaces is the simplest and most effective approach. Cross-ventilation is driven by pressure differences between the windward and leeward sides of the space.
Cross-ventilation - Double-Banked Spaces		Cross-ventilation with banked rooms can be achieved by creating openings in the corridor partition. It is only acceptable where a room has ownership of both windward and leeward sides of the building, as the ventilation of the leeward space relies on the occupant of the windward space. The openings also provide a route for noise to travel between spaces. One potential solution is to provide a channel which bypasses the windward space, allowing the occupant of the leeward space complete control of air flow.
Stack Ventilation		Stack ventilation takes advantage of the temperature stratification and associated pressure differentials of the air. Warm air becomes less dense and rises and the cooler air replaces the air that has risen. This type of ventilation requires atriums or height differences.

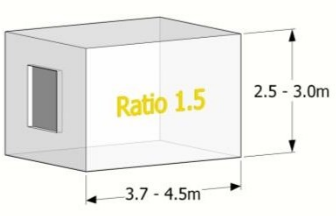
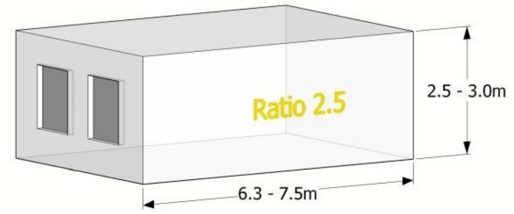
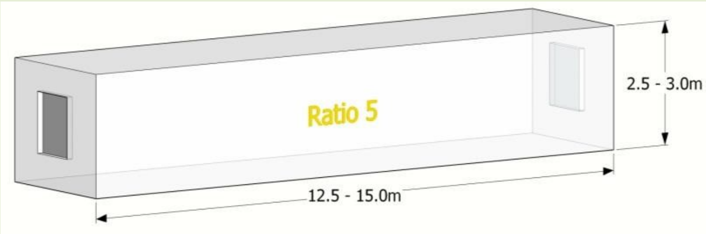
To achieve acceptable natural ventilation flow, the following methodology must be considered: i) maximum ratio of floor depth to ceiling height, and ii) the heat gains to be dissipated, which determine the total area of the opening. The latter is simplified by only providing the % of floor area as the openable area.

The depth of space that can be ventilated using a cross-flow ventilation strategy is dependent on the floor to ceiling height and the number and location of the openings. The rules of thumb below can be used to assess compliance.

Room Depth to Ceiling Height Ratio

EDGE's methodology for natural ventilation requires that the maximum ratio of the room depth versus ceiling height must be calculated first. See Table 28 for the maximum ratios for different room configurations.

Table 28: Depth of floor to ceiling height ratios for different room configurations

Room/Opening Configuration	Image/Example	Maximum Depth of Floor to Ceiling Height Ratio
Single-sided, single opening		1.5
Single-sided, multiple openings		2.5
Cross ventilation		5.0

Minimum Area of Opening

The minimum area of opening required depends on the expected heat gains in a space. Table 29 indicates the percentage of the opening area required in each space type in order to dissipate those heat gains from the space. The built-in calculator in the EDGE App incorporates these percentages automatically. The minimum required area of the opening is calculated by multiplying the total area of the room by the required percentage.

Table 29: Minimum area of opening as a proportion of floor area for different heat gain ranges.

Building Type	Space Type (Heat Gain)	Minimum Area of Opening Required as a Percentage of Floor Area
Homes	Bedrooms (15-30 W/m²)	20%
	Living Room (15-30 W/m²)	20%
	Kitchen (>30 W/m²)	25%
Hospitality	Corridors (<15 W/m²)	10%
	Guest Rooms (15-30 W/m²)	20%
Retail	Corridors, Atrium & Common Areas (<15 W/m²)	10%
Offices	Offices (15-30 W/m²)	20%
	Corridors and Lobby (<15 W/m²)	10%
Hospitals	Corridors (<15 W/m²)	10%
	Lobby, Waiting and Consultation Areas (15-30 W/m²)	20%
	Patient Rooms (15-30 W/m²)	20%
Education	Corridors (<15 W/m²)	10%
	Classrooms (15-30 W/m²)	20%

Example:

Q: A corridor with 20sqm floor area and ceiling height of 3m has 2 windows for cross ventilation. What are the design criteria to ensure compliance with natural ventilation requirements?

A: The ratio of the depth of the floor to the ceiling height should be less than 5. The ceiling height is 3m, therefore, the maximum depth of the corridor can be 15m. For example, the corridor plan can be 2m x 10m where 10m is the depth.

10% of the floor area should be openable which is 2m^2, making each window opening area at least 1m^2.

Q: A classroom with 16sqm floor area and a ceiling height of 3m has a single window for ventilation. What are the design criteria to ensure compliance with natural ventilation requirements?

A: The ratio of the depth of the floor to the ceiling height should be less than 1.5. The ceiling height is 3m, therefore, the maximum depth of the room can be 4.5. For example, the room plan can be 4mx4m where the depth is 4m.

20% of floor area should be openable, which is $3.2m^2$. This can be provided by a French door that is 2m high and 1.6m wide.

Relationship to Other Measures

Since employing natural ventilation can significantly reduce the cooling load, the impact of more efficient cooling systems is sometimes reduced to an insignificant level. As with all passive design solutions, natural ventilation should therefore be considered before the detailed design of any HVAC equipment.

Assumptions

The base case assumes that ventilation is delivered using mechanical means, while the improved case assumes that natural ventilation provides cooling during the hours when the temperature outside is suitable. If the building has mechanical cooling, the savings are reflected in the main Energy chart in the Cooling and associated energy uses. If the building does not have mechanical cooling, the cooling load is still calculated and is shown as “virtual” energy on the charts.

Cooling load is reduced through natural ventilation and other passive measures including improved insulation, reduced window-to-wall ratio, reduced SHGC, improved solar shading, and specifying ceiling fans. Reducing the cooling load will result in improved performance even when no mechanical cooling is specified and the savings are only reflected in “virtual energy”.

Compliance Guidance

If this measure is claimed, then the design team will need to demonstrate compliance with the depth of floor-to-ceiling height ratio and minimum area of opening for all corridors as explained in the Potential Technologies/Strategies section above.

Design Stage	Post-Construction Stage
At the design stage, the following must be used to demonstrate compliance: · Typical floor plans for every floor showing the layouts of the naturally ventilated spaces and the location of openings; and · Typical sections showing the floor-to-ceiling height for every floor; and · Calculations showing the depth-to-ceiling height ratio and the minimum area of opening for each typical space.	At the post-construction stage, the following must be used to demonstrate compliance: · Confirmation from the project team that no changes have been made to the layout or the floor to ceiling height during the design/construction process; or · As-built drawings including floor plans and sections; and · Photographic evidence to demonstrate that the plan layouts and location of openings as specified at the design stage have been constructed.

E10 – CEILING FANS

Corresponds to HME10, OFE10, EDE10

Requirement Summary

Ceiling fans must be installed in all the required rooms for the building type as shown below in Table 30. In countries where ceiling fans are standard (such as India), the ceiling fans must be energy-efficient for this measure to be claimed.

Table 30: Minimum Required Spaces to be Provided with Ceiling Fans, by Building Type

Building Type	Spaces that must have ceiling fans installed
Homes	All habitable rooms (bedrooms and living rooms)
Offices	Office spaces (open and closed offices)
Education	All Classrooms

Intention

Ceiling fans increase air movement, aiding human comfort by promoting the evaporation of perspiration (evaporative cooling).

Approach/Methodologies

The measure can be claimed if ceiling fans have been installed in all the required rooms for a project. For projects in India, ceiling fans must be awarded 4 or 5 stars by the Bureau of Energy Efficiency (BEE), or with an equivalent rating.

Potential Technologies/Strategies

Ceiling fans are normally used to reduce cooling energy requirements by creating greater air movement in rooms. The increased air movement results in occupants feeling comfortable at a relatively higher temperature set point. In order to have this effect, the fan must be installed with the raised edge of the blade on the leading edge. The movement of the fan pulls the air towards the ceiling. In cooling mode, the effect is on perceived comfort, so if a room is unoccupied the fans should be switched off to avoid the waste of energy.

Ceiling fans can also be used to reduce heating requirements by reducing stratification of the warmer air that tends to rise to the ceiling. In this mode, the raised edge of the blades should be at the trailing edge. The movement of the fan pushes the warm air down towards the room. Fans often have a switch to change from cooling to heating mode, which works by reversing the direction of rotation of the fan motor.

In order to achieve the levels of air movement assumed by EDGE, Table 31 shows the minimum fan requirements for different room sizes. The first number in every case is the minimum required diameter (also known as 'total blade span,' which is 2 times the radius as measured from the center of the fan to the tip of the blade) in meters, and the second number is the optimum number of fans required in different sizes of rooms. For example, a 6m x 6m room would require a minimum of 4 fans with a minimum diameter of 0.9m or 900mm each.

Table 31: Minimum fan size (in meters)/Number of ceiling fans required for different room sizes[19].

Room Width	Room Length										
	4m	**5m**	**6m**	**7m**	**8m**	**9m**	**10m**	**11m**	**12m**	**14m**	**16m**
3m	1.2/1	1.4/1	1.5/1	1050/2	1.2/2	1.4/2	1.4/2	1.4/2	1.2/3	1.4/3	1.4/3
4m	1.2/1	1.4/1	1.2/2	1.2/2	1.2/2	1.4/2	1.4/2	1.5/2	1.2/3	1.4/3	1.5/3
5m	1.4/1	1.4/1	1.4/2	1.4/2	1.4/2	1.4/2	1.4/2	1.5/2	1.4/3	1.4/3	1.5/3
6m	1.2/2	1.4/2	0.9/4	1.05/4	1.2/4	1.4/4	1.4/4	1.5/4	1.2/6	1.4/6	1.5/6
7m	1.2/2	1.4/2	1.05/4	1.05/4	1.2/4	1.4/4	1.4/4	1.5/4	1.2/6	1.4/6	1.5/6
8m	1.2/2	1.4/2	1.2/4	1.2/4	1.2/4	1.4/4	1.4/4	1.5/4	1.2/6	1.4/6	1.5/6
9m	1.4/2	1.4/2	1.4/4	1.4/4	1.4/4	1.4/4	1.4/4	1.5/4	1.4/6	1.4/6	1.5/6
10m	1.4/2	1.4/2	1.4/4	1.4/4	1.4/4	1.4/4	1.4/4	1.5/4	1.4/6	1.4/6	1.5/6
11m	1.5/2	1.5/2	1.5/4	1.5/4	1.5/4	1.5/4	1.5/4	1.5/4	1.5/6	1.5/6	1.5/6
12m	1.2/3	1.4/3	1.2/6	1.2/6	1.2/6	1.4/6	1.4/6	1.5/6	1.4/8	1.4/9	1.4/9
13m	1.4/3	1.4/3	1.2/6	1.2/6	1.2/6	1.4/6	1.4/6	1.5/6	1.4/9	1.4/9	1.5/9
14m	1.4/3	1.4/3	1.4/6	1.4/6	1.4/6	1.4/6	1.4/6	1.5/6	1.4/9	1.4/9	1.5/9

Relationship to Other Measures

The installation of ceiling fans to reduce cooling requirements improves occupant comfort without actively cooling the air. Ceiling fans are therefore only beneficial in spaces that have a demonstrable cooling load.

The installation of ceiling fans to reduce heating requirements does not necessarily decrease the heating load, but can improve occupant comfort by increasing the temperature at floor level and reducing the temperature gradient from floor to ceiling.

Assumptions

The base case assumes that no ceiling fans are specified. The improved case assumes that ceiling fans have been installed in line with the guidance above. The assumption is that the efficiency of the ceiling fans is 60W/fan (except in India where the efficiency assumed for the improved case is 40W/fan).

[19] Source: India National Building Code

Compliance Guidance

To verify compliance, the design team must demonstrate that ceiling fans will be or have been installed.

Design Stage	Post-Construction Stage
At the design stage, the following must be used to demonstrate compliance: · Mechanical and electrical layout drawings showing the location and number of ceiling fans; and · Manufacturer's data sheet showing the energy consumption and diameter of ceiling fans selected.	At the post-construction stage, the following must be used to demonstrate compliance: · As-built mechanical and electrical drawings for all floors; and · Delivery notes showing that specified fans have been delivered to the site including the energy label where applicable; and · Photographs of the installed fans for a sample of the units covered by the assessment.

E11* – AIR CONDITIONING SYSTEM

Corresponds to HME11

Requirement Summary

If the project includes a cooling system, the actual COP of a system must be entered into the software (even if the COP is lower than Base Case). Savings can be achieved if the air conditioning system provides a Coefficient of Performance (COP) greater than the Base Case.

Intention

In many cases, a cooling system will not be fitted as part of the original build, which increases the risk that future occupants will deal with any insufficient cooling later by installing air-conditioning units that may be inefficient and are poorly sized and installed. By carefully designing the installation of an efficient cooling system into the project, the energy needed to deliver the required cooling can be reduced in the longer term.

Approach/Methodologies

EDGE uses the Coefficient of Performance (COP) to measure the efficiency of air conditioning systems. The COP is the total output of cooling energy per electricity input. The COP for cooling is defined as the ratio of the rate of heating energy removal to the rate of electrical energy input, in consistent units, for a complete air conditioning system or some specific portion of that system under designated operating conditions. The formula to calculate COP is explained below. For consistency the ARI conditions should be used for comparison of COP values.

$$\mathrm{COP} = \frac{Q\ out}{W\ in}$$

Where:

Q_{out} = heating energy removal (kW)

W_{in} = electrical energy input (kW)

In order to claim this measure, the design team must demonstrate that the equipment achieves a COP greater than the base case COP value. For large buildings, more than one system may be installed. If these air conditioning systems have different COPs, the weighted average COP should be calculated.

In some cases, the cooling system could be centralized, serving a combination of buildings/dwellings within the development. The central cooling plant may be within the EDGE project boundary and controlled by the EDGE client, in which case the technical specifications must be submitted. However, when the plant for the cooling system is out of EDGE project boundary or not controlled by the EDGE client, then a contract with, or letter from the management company in charge of the plant has to be provided, stating the efficiency of the system, as part of the documentation for the post-construction stage.

Potential Technologies/Strategies

Simple air-conditioners fitted in windows and through-the wall unitary air-conditioners are the most common type of air-conditioners used in individual residential units. Apartment buildings may use packaged air-conditioners located on roof tops with ducted air flow. However, these are the least efficient types of systems. Various air-conditioning systems are available that achieve higher cooling efficiency, including split air-conditioners, multi-split air conditioners, VRF systems and chillers.

Split air-conditioners are direct expansion (DX) mechanical refrigeration systems with a single condenser unit outside serving a single fan coil unit (evaporator) inside the building, with refrigerant carried between the two in narrow tubes through the wall. These do not require ducts, and are more efficient than ducted systems. But they can only serve fan coil units located at a limited distance from the external condenser unit.

Multi-split air conditioners are like split systems, except that a single large condenser unit is connected to several fan coil units with individual tubes. The added advantage is the fewer number of outside units. But these systems can only serve spaces that are at similar temperature conditions.

Variable Refrigerant Flow (VRF) systems are a step up from multi-split systems because they can serve zones with different thermal needs, including zones that may be in heating mode while other zones are in cooling mode. VRF systems accomplish this through compressors that can modulate their speed and the refrigerant flow. The refrigerant is distributed through a piping network to multiple indoor fan-coil units, each capable of individual zone temperature control through a common communications network. The system runs only at the rate needed to deliver the temperature change required by each internal unit. The three basic types of VRF systems include: cooling only, VRF heat pump that provides both heating and cooling but not simultaneously, and VRF with heat recovery that provides heating and cooling simultaneously. VRF systems may be a particularly good option for buildings with multiple zones or wide variance in heating/cooling loads across many different internal zones. As these systems provide individual control and are the most versatile of the multi-split systems, they are relevant for residential apartment buildings. Due to the way the internal units are connected to the external unit, a breakdown of one internal unit will not compromise the rest of the system. The speed of the outdoor compressors can change to operate in a range of 6% to 100% capacity. Capacities have typically ranged from 5.3 to 223 kW for outdoor units and from 1.5 to 35 kW for indoor units, but new products are continually being introduced. Multiple outdoor units can be used if an even greater range of capacity is required.

Although VRF systems are widely used in residential buildings, other cooling systems can achieve good performance, but are not as common for these building types. A good example is chillers. **Air-cooled chillers** are vapor compression mechanical refrigeration systems with heat exchangers (evaporators) in which heat captured by the process is transferred to the refrigerant fluid. This heat transfer causes the refrigerant to evaporate, changing from liquid (a low pressure) to vapor. As a result, the temperature of the process coolant is decreased to the desired outgoing temperature. **Water-cooled chillers** are like air cooled chillers; the primary difference is that water is used to provide the condenser cooling. In general, this technology is more efficient than air-cooled chillers.

Some minimum efficiencies specified by ASHRAE 90.1-2016 are listed in Table 1, with the Variable Refrigerant Flow (VRF) system highlighted. Note that these are for comparative illustration only; the ASHRAE standard contains several COP values for each system type depending on the details of the equipment such as the capacity and technology.

Table 32. Examples of current minimum COPs for different types of air conditioning systems[20]

Type of Cooling System (Air Conditioning)	COP
Through the wall, air-cooled, packaged and split ≤ 9 kW	3.51
Air-cooled, split < 19 kW	3.81
Air-cooled, single package < 19kW DX and heat pumps	4.10
Water-cooled, split and single package < 19kW	3.54
PTAC and PTHP, standard size, all capacities In equation, Capacity = 2.1 kW < Capacity < 4.4.kW	4.10 – (0.300 × Capacity/1000)
Variable Refrigerant Flow, air-cooled, cooling mode < 19 kW	3.81
Variable Refrigerant Flow, water source, cooling mode < 19kW	3.52
Variable Refrigerant Flow, groundwater source, cooling mode < 40kW	4.75
Variable Refrigerant Flow, ground source, cooling mode < 40kW	3.93
Air Cooled Chiller < 528 kW	2.985 at Full Load (FL) 4.048 at Part Load (IPLV)
Air Cooled Chiller ≥ 528 kW	2.985 at Full Load (FL) 4.137 at Part Load (IPLV)
Water Cooled Chiller, positive displacement <264 kW (Positive displacement = reciprocating, screw and scroll compressors)	4.694 at Full Load 5.867 at Part Load (IPLV)
Water Cooled Chiller, centrifugal < 528 kW	5.771 at Full Load 6.401 at Part Load (IPLV)

[20] Source: ASHRAE 90.1-2016, Chapter 6

Note that if a cooling system other than a chiller is installed in a residential building and achieves the desired COP, then this information can be entered manually into the EDGE software, and evidence provided for certification purposes.

Relationship to Other Measures

Passive measures such as improved walls and windows will reduce the energy use from air-conditioning.

Assumptions

The base case value for the efficiency of the air conditioning system will vary by building type and by location. It is listed in the Key Assumptions for the Base Case in the Design section.

The default value for the improved case COP for the efficient cooling system also varies by system type; the actual performance of the system must be entered in all cases.

Compliance Guidance

To demonstrate compliance, the design team must describe the specified system and provide documentation to support the claims.

Design Stage	Post-Construction Stage
At the design stage, the following must be used to demonstrate compliance: · Mechanical and electrical layout drawings showing the location of the external and internal units for all floors; and · Equipment Schedule or Manufacturer’s data sheets (with the project specific info highlighted & noted) for the cooling system specifying COP information · For systems including more than one air-conditioning unit, the design team must provide the weighted average COP calculation.	At the post-construction stage, the following must be used to demonstrate compliance: · As-built mechanical and electrical drawings with air conditioning schematics for all floors; and · Delivery notes showing that specified chillers have been delivered to the site; · Manufacturer’s data sheets for the cooling system specifying COP information; · Photographs of installed external and internal air conditioning units; and /or · Contract with the management company, if the system is centralized or off-site.

E12* – AIR CONDITIONING WITH AIR COOLED CHILLER

Corresponds to HTE10, RTE11, OFE12, HSE14, EDE12

Requirement Summary

If the project includes an air-cooled chiller, the actual COP of the system must be entered in the software (even if the COP is lower than the default). Savings can be achieved if the air conditioning system is an air-cooled chiller and achieves a Coefficient of Performance (COP) greater than the baseline case under ARI conditions.

Intention

In many cases, a cooling system will not be fitted as part of the original build, increasing the risk that future occupants will deal with insufficient cooling later by installing air-conditioning units that may be inefficient and are poorly sized and installed. Chillers on the other hand deliver cooling through chilled water which has much higher heat capacity than air, allowing heat to be transferred more efficiently. By carefully designing the installation of a mechanical refrigeration system using chilled air as a distributing unit, the energy needed to deliver the required cooling can be reduced. Air-cooled chillers are suitable for climates where water supply is scarce or high humidity reduces the efficiency of the cooling towers.

Approach/Methodologies

EDGE uses the Coefficient of Performance (COP) to measure the efficiency of air conditioning systems. The COP is the total output of cooling energy per electricity input. The COP for cooling is defined as the ratio of the rate of heating energy removal to the rate of electrical energy input, in consistent units, for a complete air conditioning system or some specific portion of that system under designated operating conditions. The formula to calculate the COP is explained below. For consistency, the ARI conditions should be used for comparison of COP values.

$$\mathbf{COP} = \frac{Q\ out}{W\ in}$$

Where:

Q_{out} = heating energy removal (kW)

W_{in} = electrical energy input (kW)

To claim this measure, the design team must demonstrate that the chiller(s) achieve a COP greater than the base case. For large buildings with centralized systems, more than one chiller may be installed. If these chillers have different COPs, the weighted average COP must be calculated.

In some cases, the air conditioning system (chiller/s) for the cooling system can be centralized, serving a combination of buildings/dwellings within the development, for example, in a district cooling system. In these cases, the central plant will need to be included within the site boundary of the project, or managed by a company within the control of the site owner. This is to ensure the continuous sustainable management of (and access to) the facility by the site owner.

However, when the chiller for the cooling system is located off-site, then a contract with, or letter from the management company in charge of the chiller must be provided as part of the documentation for the post-construction stage. The document must include the efficiency of the system.

If air conditioning is not specified, any cooling load will be displayed as "virtual energy."

Potential Technologies/Strategies

This measure is based on air-cooled chillers with mechanical compression refrigeration systems. Chillers typically cool water, which is then circulated to provide comfort cooling throughout a building or other location. The system has four components: i) Compressor, ii) Condenser, iii) Thermal expansion valve, and iv) Evaporator. The compressor compresses the refrigerant and pumps it through the air conditioning system at a designed flow rate and pressure. The compressor technology is a way to distinguish the type of air-cooled chillers: Reciprocating chillers, rotary screw chillers, or scroll chillers. Selection must be made based on many factors including the size of the system; for example, reciprocating compressors are typically 3–510 refrigeration tons.

Air-cooled chillers cost significantly less per ton than water-cooled systems primarily because they require fewer components to build and operate and require less support equipment and plumbing. Installation of an air-cooled chiller is faster and easier than that of a water-cooled chiller. However, the efficiency of water-cooled chillers is typically higher because of the higher heat capacity of water compared to air.

Some minimum efficiencies specified by ASHRAE 90.1-2016 are listed in Table 33 with the Air-Cooled Chiller system highlighted. Note that these are for comparative illustration only; the ASHRAE standard contains several COP values for each system type depending on the details of the equipment such as the capacity and technology, and whether the system is optimized for full load or part load operation. This tables shows full load values.

Table 33. Examples of current minimum COPs for different types of air conditioning systems, with the air-cooled chiller highlighted[21]

Type of Cooling System (Air Conditioning)	COP
Through the wall, air-cooled, packaged and split ≤ 9 kW	3.51
Air-cooled, split < 19 kW	3.81
Air-cooled, single package < 19kW DX and heat pumps	4.10
Water-cooled, split and single package < 19kW	3.54
PTAC and PTHP, standard size, all capacities In equation, Capacity = 2.1 kW < Capacity < 4.4.kW	4.10 – (0.300 × Capacity/1000)
Variable Refrigerant Flow, air-cooled, cooling mode < 19 kW	3.81
Variable Refrigerant Flow, water source, cooling mode < 19kW	3.52
Variable Refrigerant Flow, groundwater source, cooling mode < 40kW	4.75
Variable Refrigerant Flow, ground source, cooling mode < 40kW	3.93
Air Cooled Chiller < 528 kW	2.985 at Full Load (FL) 4.048 at Part Load (IPLV)
Air Cooled Chiller ≥ 528 kW	2.985 at Full Load (FL) 4.137 at Part Load (IPLV)
Water Cooled Chiller, positive displacement <264 kW (Positive displacement = reciprocating, screw and scroll compressors)	4.694 at Full Load 5.867 at Part Load (IPLV)
Water Cooled Chiller, centrifugal < 528 kW	5.771 at Full Load 6.401 at Part Load (IPLV)

[21] Source: ASHRAE 90.1-2016, Chapter 6

Relationship to Other Measures

The local climate, heat gains and the internal temperatures based on the building design impact the cooling load. A more efficient system will not impact other measures, but several measures will impact the total energy use of the cooling system.

Assumptions

The base case for the air conditioning system's efficiency is listed in the Key Assumptions for the Base Case in the Design section.

The default value for the improved case COP for an air-cooled screw chiller system varies by factors such as building size; if the system efficiency is different from the default then the actual performance must be entered. Energy savings will be calculated accordingly.

Compliance Guidance

To demonstrate compliance, the design team must describe the specified system and provide documentation to support the claims.

Design Stage	Post-Construction Stage
At the design stage, the following must be used to demonstrate compliance: · Mechanical layout drawings showing the location of the external and internal units; and · Equipment Schedule or Manufacturer's data sheets (with the project specific info highlighted & noted) for the air-cooled chiller system specifying COP information; and · Average COP calculation for systems including more than one chiller unit.	At the post-construction stage, the following must be used to demonstrate compliance: · As-built mechanical drawings with air conditioning schematics for all floors; and · Delivery notes showing that the specified chillers have been delivered to the site; and · Manufacturer's data sheets for the air-cooled chiller system specifying the COP information; and · Photographs of installed external and internal air conditioning units; and/or · Contract with the management company if the system is centralized or off-site.

E13* – AIR CONDITIONING WITH WATER COOLED CHILLER

Corresponds to HTE11, RTE12, OFE13, HSE15, EDE13

Requirement Summary

If the project includes a water-cooled chiller, the actual COP of the system should be entered in the software (even if the COP is lower than the default value). Savings can be achieved if the air conditioning system has a Coefficient of Performance (COP) greater than the base case, as set out in the Key Assumptions for the Base Case in the Design section. The COP must be determined under ARI conditions.

Intention

Water-cooled chillers are typically more efficient than comparable air-cooled chillers. A water-cooled system is the best option when reducing operating costs is of paramount concern and the project can invest in a system with a longer payback period. Water cooling does involve a higher initial investment since both a chiller and a circulating tower system are required, which in turn require additional pumps, piping and tanks. Also, water cooling systems consume considerable amounts of water due to evaporation, purging and bleeding.

Approach/Methodologies

EDGE uses the Coefficient of Performance (COP) to measure the efficiency of an air-conditioning system. The COP is the total output of cooling energy per electricity input. The COP for cooling is defined as the ratio of the rate of heating energy removal to the rate of electrical energy input, in consistent units, for a complete air conditioning system or some specific portion of that system under designated operating conditions. The formula to calculate the COP is explained below. For consistency, ARI conditions must be used for the comparison of COP values.

$$\mathbf{COP} = \frac{Q\ out}{W\ in}$$

Where:

Q_{out} = heating energy removal (kW)

W_{in} = electrical energy input (kW)

To claim this measure, the design team must demonstrate that the chiller(s) achieve a COP greater than the base case. For large buildings with centralized systems, more than one chiller may be installed. If these chillers have different COPs, the weighted average COP must be calculated.

In some cases, the air conditioning system (chiller/s) for the cooling system can be centralized, serving a combination of buildings/dwellings within the development, for example, in a district cooling system. In these cases, the central plant will need to be included within the site boundary of the project, or managed by a company within the control of the site owner. This is to ensure the continuous sustainable management of (and access to) the facility by the site owner.

However, when the chiller for the cooling system is located off-site, then a contract with, or letter from the management company in charge of the chiller must be provided as part of the documentation for the post-construction stage. The document must include the efficiency of the system.

If air conditioning is not specified, any cooling load will be displayed as “virtual energy.”

Potential Technologies/Strategies

This technology is similar to air-cooled chillers, the primary difference being that water is used to cool the condenser instead of air.

The cycle begins in the evaporator where a liquid refrigerant flows over the evaporator tube bundle and evaporates, absorbing heat from the water circulating through the bundle. The refrigerant vapor is drawn out of the evaporator by the compressor. The compressor compresses the refrigerant raising its pressure and temperature, and pumps the refrigerant vapor to the condenser. The refrigerant condenses in the condenser tubes, giving up its heat to the water that is cooling the condenser. The high-pressure, liquid refrigerant from the condenser then passes through the expansion device that reduces the refrigerant pressure and temperature as it enters the evaporator. The cold refrigerant again flows over the water coils absorbing more heat and completing the cycle.

Relationship to Other Measures

The local climate, heat gains and the internal temperatures based on the building design impact the cooling load. A more efficient system will not impact other measures, but several measures will impact the total energy use of the cooling system.

In addition, when a water-cooled chiller is selected as an energy efficiency measure, total water consumption is increased for both the base and the improved case, as the chiller will require water to operate.

Assumptions

The base case for air conditioning system efficiency is listed in the Key Assumptions for the Base Case in the Design section.

The default value for the improved case COP for the water-cooled chiller varies as per ASHRAE 90.1-2007 based on the area and number of floors; if the system efficiency is different from the measure’s default value, then the actual performance must be entered, and the energy savings will be recalculated.

Compliance Guidance

To demonstrate compliance, the design team must describe the specified system and provide documentation to support the claims.

Design Stage	Post-Construction Stage
At the design stage, the following must be used to demonstrate compliance: · Mechanical layout drawings/schematic showing the location of the external and internal units; and · Equipment schedule or Manufacturer's data sheets (with the project specific info highlighted & noted) for the water-cooled chiller system specifying COP information; and · Average COP calculation for systems including more than one chiller unit.	At the post-construction stage, the following must be used to demonstrate compliance: · As-built mechanical drawings with air conditioning schematics for all floors if there are changes; and · Delivery notes showing that the specified chillers have been delivered to the site; and · Manufacturer's data sheets for the water-cooled chiller system specifying the COP information; and · Photographs of installed external and internal units including chillers and cooling towers; and/or · Contract with the management company if the system is centralized or off-site.

E14* – VARIABLE REFRIGERANT FLOW (VRF) COOLING SYSTEM

Corresponds to HTE09, RTE10, OFE11, HSE13, EDE11

Requirement Summary

If the project includes a Variable Refrigerant Flow (VRF) system, the actual COP of the system should be entered in the software (even if the COP is lower than baseline). Savings can be achieved if the air conditioning system achieves a Coefficient of Performance (COP) greater than baseline under ARI conditions. Note that the same measure applies to a Variable Refrigerant Volume (VRV) cooling system, which is a patented name for a type of VRF system.

Intention

In many cases, a cooling system will not be fitted as part of the original build, which increases the risk that future occupants will deal with insufficient cooling later by installing air-conditioning units that may be inefficient and are poorly sized and installed. By carefully designing the installation of an efficient cooling system into the project, the energy needed to deliver the required cooling can be reduced in the longer term.

Approach/Methodologies

EDGE uses the Coefficient of Performance (COP) to measure the efficiency of air conditioning systems. The COP is the total output of cooling energy per electricity input. The COP for cooling is defined as the ratio of the rate of heating energy removal to the rate of electrical energy input, in consistent units, for a complete air conditioning system or some specific portion of that system under designated operating conditions. The formula to calculate the COP is explained below. For consistency, ARI conditions should be used for comparison of COP values.

$$\mathbf{COP} = \frac{Q\ out}{W\ in}$$

Where:

Q_{out} = heating energy removal (kW)

W_{in} = electrical energy input (kW)

To claim this measure, the design team must demonstrate that the system achieves a COP greater than the base case of 3.5. For large buildings with centralized systems, more than one system may be installed. If these systems have different COPs, the weighted average COP must be calculated.

In some cases, the air conditioning system for the cooling system may be centralized, serving a combination of buildings/dwellings within the development. In these cases, the central plant will need to be included within the site boundary of the project, or managed by a company within the control of the site owner. This is to ensure the continuous sustainable management of (and access to) the facility by the site owner.

However, when the plant for the cooling system is located off-site, then a contract with, or letter from the management company in charge of the cooling plant must be provided as part of the documentation for the post-construction stage. The document must include the efficiency of the system.

EDGE calculates the cooling load by accounting for the local climate, heat gains and the internal temperatures based on the building design. If air conditioning is not specified, any cooling load will be displayed as "virtual energy."

Potential Technologies/Strategies

A Variable Refrigerant Flow (VRF) system uses refrigerant as the medium for heat transfer. These systems have one condensing unit with multiple indoor units, each of which can be individually controlled. The system runs by modulating the amount of refrigerant that is sent to each evaporator, running only at the rate needed to deliver the cooling required by each internal unit. VRF systems may be the best for buildings with multiple zones or a wide variance in cooling or heating loads across many different internal zones requiring individual control such as offices, retail buildings, education, healthcare buildings, or hotels and resorts. The outdoor units can be fitted to as many as 48 internal units. Due to the way in which the internal units are connected to the external unit, a breakdown of one internal unit will not compromise the rest of the system. The outdoor units can vary the speed of the compressors and operate in a range of 6% to 100% capacity. Multiple outdoor units can be used if an even greater range of capacity is required.

Some minimum efficiencies specified by ASHRAE 90.1-2016 are listed in Table 34, with the Variable Refrigerant Flow (VRF) system highlighted. Note that these are for comparative illustration only; the ASHRAE standard contains several COP values for each system type depending on the details of the equipment such as the capacity and technology.

Table 34: Examples of current minimum COPs for different types of air conditioning systems, with VRF highlighted[22].

Type of Cooling System (Air Conditioning)	COP
Through the wall, air-cooled, packaged and split ≤ 9 kW	3.51
Air-cooled, split < 19 kW	3.81
Air-cooled, single package < 19kW DX and heat pumps	4.10
Water-cooled, split and single package < 19kW	3.54
PTAC and PTHP, standard size, all capacities In equation, Capacity = 2.1 kW < Capacity < 4.4.kW	4.10 – (0.300 × Capacity/1000)
Variable Refrigerant Flow, air-cooled, cooling mode **< 19 kW**	3.81
Variable Refrigerant Flow, water source, cooling mode **< 19kW**	3.52
Variable Refrigerant Flow, groundwater source, cooling mode **< 40kW**	4.75
Variable Refrigerant Flow, ground source, cooling mode **< 40kW**	3.93
Air Cooled Chiller < 528 kW	2.985 at Full Load (FL) 4.048 at Part Load (IPLV)
Air Cooled Chiller ≥ 528 kW	2.985 at Full Load (FL) 4.137 at Part Load (IPLV)
Water Cooled Chiller, positive displacement <264 kW (Positive displacement = reciprocating, screw and scroll compressors)	4.694 at Full Load 5.867 at Part Load (IPLV)
Water Cooled Chiller, centrifugal < 528 kW	5.771 at Full Load 6.401 at Part Load (IPLV)

[22] Source: ASHRAE 90.1-2016, Chapter 6

Relationship to Other Measures

The local climate, heat gains and the internal temperatures based on the building design impact the cooling load. A more efficient system will not impact other measures, but several measures will impact the total energy use of the cooling system.

A VRF system will have a smaller impact on savings if the building walls and windows have been optimized. To realize savings from a VRF system, the spaces must be zoned separately with their own individual thermostats.

Assumptions

The base case efficiency of the air conditioning system is based on ASHRAE 90.1-2007 and is listed in the Key Assumptions for the Base Case in the Design section.

The default improved case COP for the VRF cooling system varies depending on factors such as the building area; if the designed system efficiency is different than the default, then the actual performance must be entered. Energy savings will be calculated accordingly.

Compliance Guidance

To demonstrate compliance, the design team must describe the specified system and provide documentation to support the claims.

Design Stage	Post-Construction Stage
At the design stage, the following must be used to demonstrate compliance: · Mechanical layout drawings/schematic showing the location of the external and internal units; and · Equipment schedule or Manufacturer's data sheets (with the project specific info highlighted & noted) for the VRF cooling system specifying COP information; and · Average COP calculation in the case of systems with more than one unit.	At the post-construction stage, the following must be used to demonstrate compliance: · As-built mechanical drawings with air conditioning schematics for all floors; and · Delivery notes showing that the specified equipment has been delivered to the site; and · Manufacturer's data sheets for the VRF cooling system specifying COP information; and · Photographs of installed external and internal air conditioning units; and/or · Contract with the management company if the system is centralized or off-site, including the efficiency of the system.

E15 – ABSORPTION CHILLER POWERED BY WASTE HEAT

Corresponds to HTE13, RTE14, OFE15, HSE17, EDE15

Requirement Summary

This measure can be claimed if a power generator fueled by Diesel or Natural Gas provides power to the building, and a recovery technology is installed to capture the waste heat from the generator for the cooling cycle. Additionally, the absorption chiller system must achieve a Coefficient of Performance (COP) greater than 0.7 under ARI conditions. The COP is used to establish the efficiency of this measure.

Intention

In many cases, a cooling system will not be included in the original build, possibly increasing the risk that future occupants will deal with insufficient cooling with an amateur installation of inefficient and poorly sized air conditioning units. By providing a mechanical refrigeration system that uses the waste heat generated in other processes such as electricity generation or industrial processes to run an absorption chiller, the energy needed to deliver the required cooling and/or heating can be reduced significantly.

Approach/Methodologies

EDGE uses COP to measure the efficiency of an air conditioning system. The COP of absorption chillers is the total output of cooling energy per waste heat input. As defined in ASHRAE, the COP is "the ratio of the rate of heat removal to the rate of energy input, in consistent units, for a complete refrigerating system or some specific portion of that system under designated operating conditions." Compared to mechanical chillers, absorption chillers have a low coefficient of performance (COP = chiller load/heat input), but they are powered by waste heat. The formula to calculate COP is explained below. For consistency, the ARI conditions must be used for comparison of COP values.

$$\mathbf{COP} = \frac{Q\ out}{W\ in}$$

Where:

Q_{out} = heating energy removal (kW)

W_{in} = electrical energy input (kW)

To claim this measure, the design team must demonstrate that the absorption chiller(s) achieve an efficiency greater than 70% (COP >0.7). For large buildings with centralized systems, more than one chiller may be installed. If these chillers have different COPs, the weighted average COP must be calculated.

In some cases, the air conditioning system (chiller/s) for the cooling system can be centralized, serving a combination of buildings/dwellings within the development. In these cases, the central plant will need to be included within the site boundary of the project, or managed by a company within the control of the site owner. This is to ensure the continuous sustainable management of (and access to) the facility by the site owner.

However, when the chiller for the cooling system is located off-site, then a contract with (or letter from) the management company in charge of the chiller must be provided, stating the efficiency of the system, as part of the documentation for the post-construction stage.

If air conditioning is not specified, any cooling load will be displayed as "virtual energy."

If this measure is selected, the assumptions in the Key Assumptions on the Design tab must be verified. The user must select the appropriate fuel under 'Fuel Used for Electric Generator', and input the appropriate value for '% of Electricity Generation Using [Fuel].'

Potential Technologies/Strategies

An absorption chiller is a type of air-cooling device that absorbs waste heat instead of electrical energy to provide cooling. An absorption chiller has a low COP. However, it can reduce operating costs because it is powered by waste heat. An absorption chiller is a much more cost-effective alternative to a traditional cooling system due to the use of waste heat as fuel and lower maintenance.

Waste heat is the result (byproduct) of building processes or industrial processes that is not being put to practical use. This waste heat is captured to generate cooling as an emission-free substitute for costly purchased fuels or electricity. It is thus a no-cost fuel source which can improve the overall energy efficiency in a facility.

Absorption chillers are more cost-effective in large-sized buildings which are owned and operated by the same manager.

Relationship to Other Measures

The local climate, heat gains and internal temperatures based on the building design impact the cooling load. A more efficient system will not impact other measures, but several measures will impact the total energy use of the cooling system.

In addition, when an absorption chiller powered by waste heat is selected as an energy efficiency measure, the heating and/or cooling energy is reduced depending on the load of the building. The energy from pumps is slightly increased due to the operation of the system.

Assumptions

The base case efficiency of the air conditioning system is based on ASHRAE 90.1-2007, and is listed in the Key Assumptions for the Base Case in the Design section. The heating fuel selection can be changed by the user.

The improved case COP for the absorption chiller system is 0.7. Although the equipment efficiency is not high, it uses waste heat to power the chiller, thus achieving a higher whole-system efficiency.

Compliance Guidance

To demonstrate compliance, the design team must describe the specified system and provide documentation to support the claims.

Design Stage	Post-Construction Stage
At the design stage, the following must be used to demonstrate compliance: · Mechanical and electrical layout drawings showing the location of the external and internal units for all floors; and · Equipment Schedule or Manufacturer's data sheets for the absorption chiller system specifying COP information and the waste heat generator; and · Average COP calculation for systems including more than one chiller unit; and · Calculation to demonstrate that the generators have the capacity to deliver 100% of peak energy and that waste heat needed to run the absorption chiller is achieved.	At the post-construction stage, the following must be used to demonstrate compliance: · As-built mechanical and electrical drawings with air conditioning schematics for all floors and the location of the waste heat generation; and · Delivery notes showing that the specified absorption chillers have been delivered to the site; and · Manufacturer's data sheets for the absorption chiller system specifying COP information and the waste heat generator; or · Photographs of installed external and internal air conditioning units; and/or · Contract with the management company if the system is centralized or off-site.

E16 – AIR ECONOMIZERS DURING FAVORABLE OUTDOOR CONDITIONS

Corresponds to RTE09, OFE23, HSE12

Requirement Summary

This measure can be claimed if the air handling units in the HVAC system use air economizers. Critical areas with special needs for indoor air quality, such as Operation Theatres (OT) and/or the Intensive Care Units (ICU) in hospitals, are exempt from this requirement. By default, the base case system does not have air economizers.

Intention

Cooling energy can be reduced in buildings if outside air conditions are suitable to cool the building with little or no need for mechanical cooling.

Approach/Methodologies

The effectiveness of air economizers is highly dependent on the outside air temperature and humidity levels, which are measured through an outdoor sensor in the economizer system. When the conditions are suitable, the outside air damper is opened fully and the cooling compressors are turned down or shut off.

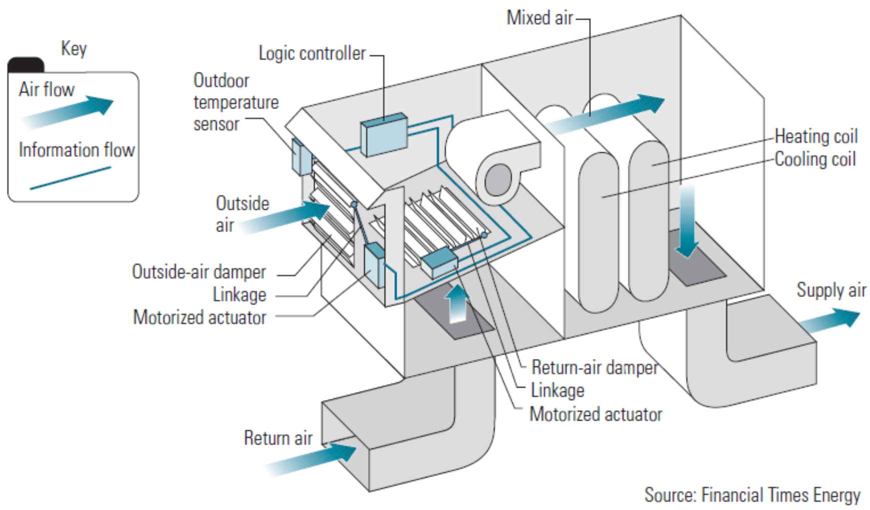


Figure 10. Components of an air economizer system[23]

[23] Source: Image courtesy of Energy Design Resources (www.energydesignresources.com),

Potential Technologies/Strategies

Decision on the inclusion of air economizers should be based on analysis of outdoor air temperature and humidity in comparison to the desired indoor temperatures. While this measure has potential to reduce cooling energy significantly in some locations, increased capital and operating costs are possible if the system is not designed and maintained properly.

Air economizers should typically be avoided in following circumstances:

- Especially corrosive climates, such as near an ocean
- Hot and humid weather
- Scarcity of sufficiently trained maintenance staff

Relationship to Other Measures

When weather conditions are appropriate, an air economizer will reduce the need for mechanical cooling. Therefore, the savings from cooling efficiency improvement measures will be reduced.

Assumptions

EDGE software uses monthly average outdoor air temperatures based on the project location to estimate the suitability of an air economizer for the project. If more accurate monthly average outdoor temperatures are available, they can be entered in the "Key Assumptions for the Base Case" section of the design tab.

Compliance Guidance

To demonstrate compliance, the design team must describe the specified system and provide documentation to support the claims.

Design Stage	Post-Construction Stage
At the design stage, the following must be used to demonstrate compliance: · Manufacturer's data sheet for the air economizer specified; and · System schematics showing the location, brand and model of the air economizer.	At the post-construction stage, the following must be used to demonstrate compliance: · Updated system schematics; · Photographs of the installed economizer; · Purchase receipts and delivery notes for the economizers; and · Manufacturer's data sheet for the economizers purchased.

E17 – CO_2 SENSOR/DEMAND-CONTROLLED VENTILATION FOR FRESH AIR INTAKE

Corresponds to RTE20

Requirement Summary

Mechanical ventilation in principal areas of the building can be controlled by CO_2 sensors. At least 50% of the building ventilation system should be controlled by CO_2 sensors to claim this measure.

Intention

Mechanical ventilation introduces fresh air into the space. By installing CO_2 sensors in the principal areas and covering at least 50% of the building, mechanical ventilation can be switched off when it is not required, thus consuming lesser energy. While the primary benefit of the CO_2 sensors is the reduction of energy bills, the following are the other associated benefits:

- Improved and consistent indoor air quality
- Occupant comfort
- Reduced greenhouse gas emissions; and
- Extended equipment life due to less demand on the HVAC system

It is recommended that the control system take frequent measurements of CO_2 levels to adjust the ventilation supply to maintain proper indoor air quality.

Approach/Methodologies

No calculations are involved in the assessment of this measure. To claim that it has been achieved, the principal areas of the building must have CO_2 sensors to control ventilation, covering at least 50% of the building floor area.

Potential Technologies/Strategies

The amount of mechanical ventilation can be controlled to only provide fresh air to spaces at the time that it is required. This reduces the energy consumed by the HVAC system. Traditional ventilation systems are designed to provide a constant volume of fresh air based on maximum occupancy[24]. However, at partial occupancy levels, energy is wasted to condition outside air provided through the mechanical ventilation system even when it is

[24] Commercial HVAC, Manitoba Hydro. 2014. https://www.hydro.mb.ca/your_business/hvac/ventilation_co2_sensor.shtml

not needed. The level of Carbon Dioxide (CO_2) in the air exhaled by people serves as a useful indicator of the room's occupancy levels, and therefore its ventilation needs.

CO_2 sensors are therefore a type of controls based on demand for the mechanical ventilation system, which reduce energy consumption while ensuring good air quality. The savings vary depending on the configuration of the HVAC system. For constant volume air-handling units (AHUs), the savings occur at the primary systems (boilers, chillers, air-conditioners, etc.), while for variable-air-volume (VAV) AHUs, the savings occur not only at the primary systems but also at the terminal boxes that include reheat[25]. The following image explains the way CO_2 sensors operate in both cases:

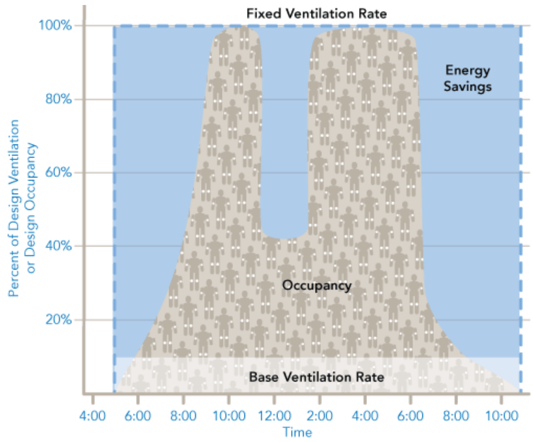


Figure 11. Energy savings due to CO_2 sensors. Source[23]

ASHRAE Standard 90.1-2004 recommends that the building incorporate any type of Demand Controlled Ventilation (DCV), which includes CO_2 sensors, when the building has a density greater than 100 people and when the AHU has an outdoor air capacity greater than 3,000 ft³/min. The following specifications are recommended in ASHRAE 90.1-2004 for the selection of the CO_2 sensor:

- Range: 0-2,000 ppm
- Accuracy (including repeatability, non-linearity and calibration uncertainty): +/- 50 ppm
- Stability (allowed error due to aging): <5% Full Scale for 5 years
- Linearity (maximum deviation between a reading and the sensor's calibration curve): +/- 2% Full Scale
- Manufacturer recommended minimum calibration frequency: 5 years

Relationship to Other Measures

CO_2 sensors are controls for the mechanical ventilation system that can reduce the amount of cooling or heating energy, as well as fan energy, used by the HVAC system as less outside air is moved into the building. In addition, if the building uses a water-cooled chiller for the AC, then a reduction in the water consumption is also achieved.

[25] Design brief: Demand-controlled ventilation, Energy Design Resources. 2007. http://energydesignresources.com/media/1705/EDR_DesignBriefs_demandcontrolledventilation.pdf?tracked=true

Assumptions

The base case assumption is that the mechanical ventilation is provided at a fixed rate. The improved case assumes that CO_2 sensors are installed on all fresh air systems to control the fresh air based on the demand.

Compliance Guidance

Design Stage	Post-Construction Stage
At the design stage, the following must be used to demonstrate compliance: · HVAC layout drawings showing the location of the CO_2 sensors including the mounting height; and · Specification of the sensors from the manufacturer.	At the post-construction stage, the following must be used to demonstrate compliance: · Photographs of the CO_2 sensor controls in the principal areas of the building. It is not necessary to take photos of every sensor, but the auditor must be convinced that a reasonable proportion has been checked and verified; and · As-built electrical layout drawings showing the location of the CO_2 sensors if changed from design; and/or · Purchase receipts and delivery notes for sensors, showing that covers or guards have been provided.

E18 – EARTH AIR TUNNEL SYSTEM TO PRE-CONDITION SUPPLY AIR INTAKE

Corresponds to HSE23

Requirement Summary

This measure can be claimed if the building has an Earth Air Tunnel (EAT) system to help ventilate or pre-cool or pre-heat the intake air for the air conditioning system.

Intention

Earth Air tunnel systems help buildings reduce fossil fuel consumption and lower operating costs by pre-heating or pre-cooling the outside air entering the building. This reduces the load for space heating or for space cooling. Buildings that use energy for heating or cooling with fresh air supply have the potential to benefit from an Earth Air Tunnel system.

Approach/Methodologies

In a building with significant space heating or space cooling load, installing an EAT system will reduce energy consumption. In an EAT, fresh outside air is passed through a tunnel or pipe several meters under the ground. This pre-heats / pre-cools the air through conductive heat exchange with the relatively stable temperatures a few meters under the surface of the ground. This tempered air is supplied to the building for heating, cooling or ventilation.

In order to qualify, the design team must demonstrate that an EAT system is installed on the building site. EDGE calculates the savings of the system based on the local climate conditions as well as the ground temperature at which the system will be located. If the ground temperature is known, it can be input in the EDGE software.

Potential Technologies/Strategies

The Earth Air Tunnel system, also called an Earth-Air heat exchanger, Air-to-soil heat exchanger, or Earth Canal, is a system that relies on the relatively constant annual temperature a few meters below the ground. The system uses the thermal inertia of the soil, and depends on its thermal conductivity (temperature difference between the soil and the air). The thermal conductivity of the soil can be affected by different factors which are detailed in the table below.

Table 35: Factors affecting thermal conductivity of the soil

Recovery technology	Description
Moisture content	Most notable impact is on thermal conductivity as it increases with moisture up to a certain point (critical moisture content)
Dry density of soil	Thermal conductivity increases when soil is dry and dense
Mineral Composition	If the mineral content is high then the conductivity is high, while if the organic content is high then conductivity is low.
Soil Texture	Coarse textured, angular grained soil has higher thermal conductivity
Vegetation	Vegetation acts as an insulating agent moderating the effect of temperature

The system has a wind catcher for the input air, which is driven down into an underground tunnel that runs under the building, where the air is cooled or heated based on the weather conditions (see **Figure 12**). The system is more commonly used in hot and dry climates for cooling, where air pre-cooled in the EAT system is input to the mechanical ventilation system or circulated directly into the building.

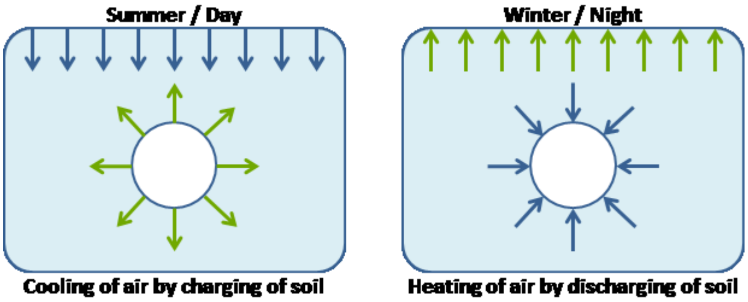
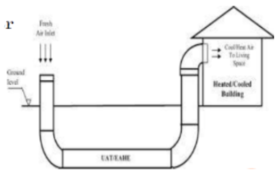
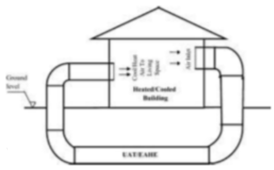
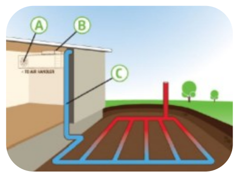


Figure 12. Interaction of soil with Earth Air tunnel system

If the tunnel is used for cooling, the ground can be shaded using vegetation, and can be wetted by sprinkling water to reduce the underground temperature further. The following are some of the design parameters to consider when designing an Earth Air tunnel system, as they impact its performance.

Table 36: Design parameters to be considered for Earth Air tunnel system[26]

Parameter	Description
Tube Depth	The deeper the better to get the lowest fluctuation in temperature. Generally, a balance between the depth and the temperature can be obtained at four meters below the ground. However, that can vary upon the external climate, the water content, the soil composition and its thermal properties.
Surface area (Tube Length and diameter)	Higher surface area of the pipe (diameter and length), higher heat transfer, therefore higher efficiency. However, the length should be optimized as after certain length no significant no significant heat transfer occurs and more fan energy is required. Also, increased diameter results in reduction of air speed and heat transfer. The surface area of the pipe will be determined by the balance of the best performances vs. costs.
Air Flow rate	Increase of air flow increases the heat transfer and the outlet temperature.
Tube arrangement:	**Open-loop system:** Outdoor air is driven to AHU or to the building. Apart from providing ventilation, it also provides heating or cooling. **Closed-loop system:** Air from the interior of the building is circulated through the Earth-Air tunnel to reduce condensation problems as well as it increases efficiency. **One-tube system:** This arrangement is not efficient for cooling due to the length of the tube, but it is cost-efficient for ventilation purposes **Parallel tubes system:** This arrangement increases thermal performance as it reduces the air pressure.  Open-loop system  Closed-loop system  Parallel tubes system
Tube Material	The selection of material is based on the cost, the strength, resistance to corrosion and durability, but not based on the performance, as it has little influence on it.
Efficiency	It is measured using the Coefficient of Performance (COP), which is based on the amount of heating/cooling generated by the system and the amount of energy needed to move the air though the system.

[26] Adapted from: Singh, Angad Deep, *Earth Air Tunnels*, (n.d.), Retrieved April 11, 2018 from ASHRAE India website http://ashraeindia.org/pdf/Angad_Deep_Singh.pdf

Relationship to Other Measures

The air intake is pre-cooled in hot weather; this decreases the cooling load and consumption due to 'Cooling Energy.' The same principle applies to the heating load if the building uses predominately space heating, in which case the reduction is in 'Heating Energy.' In addition, both 'Fan Energy' and 'Pump Energy' are reduced because the load for the cooling / heating system is lower, and the HVAC system does not need to work at full capacity.

Assumptions

The HVAC systems included in the base case do not include an Earth Air tunnel system. The improved case is assumed to have an Earth Air tunnel system that uses the local ground temperature (based on the weather file) at 4 meters below the ground.

Compliance Guidance

Design Stage	Post-Construction Stage
At the design stage, the following must be used to demonstrate compliance: · Mechanical and electrical layout drawings showing the location and design of the Earth Air Tunnel system; and · Evidence of the ground temperature at the location of the system.	At the post-construction stage, the following must be used to demonstrate compliance: · As-built mechanical and electrical drawings with the location and design of the Earth Air Tunnel system, if changed from design; and · Photographs of the installation of Earth Air Tunnel system.

E19 – VARIABLE SPEED DRIVES ON THE FANS ON COOLING TOWERS

Corresponds to HTE15, RTE16, OFE18, HSE19, EDE17

Requirement Summary

This measure can be claimed if water-cooled chillers are installed for the cooling system, and the fans in the cooling towers of the chillers use only Variable Speed Drive (VSD) motors. These are typically variable-frequency drive (VFD) or adjustable-frequency drive motors, although other VSD technologies are available.

Intention

VSD fans offer improved system reliability and process control. By specifying VSD fans for cooling towers, energy consumption is reduced resulting in reduced utility costs. The lifetime of system components is increased because of lesser use at full capacity leading to lesser wear and tear with less maintenance needed.

Approach/Methodologies

Cooling towers need to operate at the maximum (peak) load only at certain times. For most of the hours in a day, they only need to operate at part loads. VSDs on fans control and regulate the fan speeds depending on the load on the cooling towers, as opposed to constant speed fans, thus reducing energy consumption.

To claim this measure, the design team must demonstrate that the project includes Air Conditioning with Water Cooled Chillers, and that the fans on the cooling towers of the HVAC system are VSD fans.

Potential Technologies/Strategies

Water chiller systems include cooling towers which are specialized heat exchangers in which air and water are brought into direct contact with each other to reduce the water's temperature through evaporation. Water carrying heat from the building is pumped through pipes to the cooling tower. There it is sprayed through nozzles onto banks of material that break up the water, exposing a large amount of the water surface to air. The air that is driven across the water to cool it approaches 100% relative humidity and elevated temperatures and is rejected to the atmosphere. A small amount of water evaporates in the process and the rest cools down and is pumped back into the chiller where it again absorbs heat in a continuous cycle.

The air used to cool the water is pulled through the cooling tower by electric motor-driven fans. These fans can be electronically controlled with Variable Speed Drive (VSD) motors. A VSD motor regulates the speed and the rotational force of the fan by varying the motor input frequency and voltage.

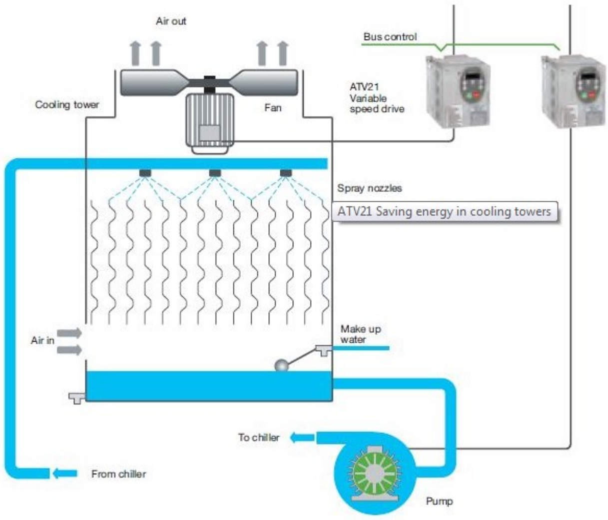


Figure 13. Schematic of cooling tower and VSDs system[27]

Relationship to Other Measures

When VSDs for the fans of the cooling towers is selected as an energy efficiency measure, the cooling system selected must be Air Conditioning with Water Cooled Chiller to show the savings. Reduced fan energy will also reduce the heat loss from fan motors and, therefore, the load on the cooling energy.

Assumptions

The base case for the air conditioning system varies based on ASHRAE 90.1-2007, and is typically a standard Packaged Terminal Air Conditioner (PTAC), as listed in the Key Assumptions for the Base Case in the Design section*. Cooling towers and therefore, VSDs on cooling towers, are not typically part of the baseline. In the Improved Case, this measure will show savings only if 'Air Conditioning with a Water-Cooled Chiller' is also selected as a measure because cooling towers are a part of the chiller system. The assumption for the Improved Case is that all fans in the cooling towers will be provided with VSDs.

[27] Source: Image courtesy of Joliet Technologies, L.L.C. 2014 and Schneider Electric SE. 2014

Compliance Guidance

To demonstrate compliance, the design team must describe the specified system and provide documentation to support the claims.

Design Stage	Post-Construction Stage
At the design stage, the following must be used to demonstrate compliance: · Manufacturer’s data sheets for the air conditioning with water cooled chiller and cooling towers, showing the specification of VSDs in the fans of the cooling towers; and · For systems including more than one cooling tower, the design team must ensure that all fans are provided with VSDs; and · Mechanical and electrical layout drawings highlighting the use of VSDs in the fans of the cooling towers.	At the post-construction stage, the following must be used to demonstrate compliance: · Delivery notes showing that specified VSDs have been delivered to the site along with the cooling towers and the water-cooled chillers; and · Manufacturer’s data sheets for the air conditioning with water cooled chiller, showing the specification of VSDs in the fans of the cooling towers; or · Photographs of installed VSDs in the cooling towers.

E20 – VARIABLE SPEED OR FREQUENCY DRIVES (VSD OR VFD) IN AHUs

Corresponds to RTE17, OFE19, HSE20, EDE18

Requirement Summary

This measure can be claimed if the fans in the Air Handling Units (AHUs) of the HVAC system are installed with Variable Speed Drive (VSD) motors. These are typically variable-frequency drive (VFD) or adjustable-frequency drive motors although other VSD technologies are also available.

Intention

The aim is to encourage the project team to specify VSDs, which modulate the motor speed of AHU fans based on actual demand.

Approach/Methodologies

Air Handling Units (AHUs) are part of the typical HVAC system which contain heating/cooling coils, filters and fans. The fans use a significant amount of energy if they continuously run at a constant speed. Variable Speed Drive (VSD) motors use an electronic device to modulate the speed of the fan motors based on actual heating/cooling demand. The power demand of motors is directly proportional to the cube of the motor speed. So, even a 20% reduction in motor speed cuts down power consumption by about half[28].

To claim this measure, the design team must demonstrate that all the installed AHU fans have VSD motors.

Potential Technologies/Strategies

VSDs offer a high degree of control and are extremely versatile. They are available both as integrated and standalone devices that can be connected to the fan motor.

Assumptions

The base case for the air conditioning system is dependent on the building size and type. This measure will show savings only if the air conditioning system has AHUs. The assumption is that all fans in the HVAC system will be provided with VSDs.

[28] http://www.ecmweb.com/power-quality/basics-variable-frequency-drives

Compliance Guidance

To demonstrate compliance, the design team must describe the specified system and provide documentation to support the claims.

Design Stage	Post-Construction Stage
At the design stage, the following must be used to demonstrate compliance: · Mechanical and electrical layout drawings showing the entire HVAC system and highlighting the use of VSDs in AHU fans; and · Manufacturer's data sheets for VSDs for fans.	At the post-construction stage, the following must be used to demonstrate compliance: · Delivery notes showing that specified VSDs have been delivered to the site; and · Manufacturer's data sheets for VSDs for fan motors; or · Photographs of installed VSDs for fan motors.

E21 – VARIABLE SPEED DRIVE PUMPS

Corresponds to HTE16, RTE18, OFE20, HSE21, EDE19

Requirement Summary

This measure can be claimed if the HVAC system has installed Variable Speed Drive (VSD) pumps, that is pumps with VSD motors.

Intention

The aim is to encourage the project team to specify VSD pumps, as energy consumption will be reduced, and therefore the utility costs. The lifetime of the system components is increased and less maintenance is needed.

Approach/Methodologies

In most cases, the HVAC system needs to operate at the maximum (peak) load only at certain times because its load is not continuous. VSDs control and regulate the speed of the flow depending on the load of the HVAC system. Therefore, installing VSD pumps on the cooling/heating system will reduce energy consumption.

The following are the pros and cons of VSD motors for pumps:

Table 37: Benefits and limitations of VSD motors for pumps

Benefits and Limitations of VSDs for Pumps		
BENEFITS	Improved Process Control:	Provide regulation functions that improve the entire system and protect the other components of the system.
	Improved System Reliability:	Lower chance of failure
	Simplified pipe systems:	Elimination of control valves and by-pass lines
	Improved system lifetime:	Avoidance of soft start and stop, and resulting mechanical overload and peak pressures implied by on-off systems
	Reduced energy costs and maintenance:	Ability to modulate speed and torque at part-loads reduces energy use, and wear and tear
LIMITATIONS	Minimum speed may be required (typically 30%)	Manufacturers may require a minimum speed to avoid problems with overheating and lubrication

To claim this measure, the design team must demonstrate that only VSDs pumps are installed. The HVAC system must require pumps, such as air or water-cooled chillers, heat pumps or absorption chillers, which must be previously selected.

Potential Technologies/Strategies

Various methods can be used to regulate the speed of the flow in the pumps to modulate its use in tandem with the load on the system, therefore reducing the energy consumption.

Variable Speed Drive (VSD) pumps use electronics to control the power used by the motor of the pump to adjust the speed of the flow into an HVAC system in response to the demand.

VSDs offer a high degree of control and are extremely versatile. They are available as standalone devices that are connected to the motor of the pump except for motors below 15kW, which are embedded or integrated into the motor.

Relationship to Other Measures

When VSDs for the pumps is selected as an energy efficiency measure, it is required that the HVAC system selected are either air or water-cooled chillers, heat pumps or absorption chillers for savings to show. Reduced pump energy use will also reduce the heat loss from pump motors and, therefore, the load on the cooling energy.

Assumptions

The base case for the air conditioning system varies based on ASHRAE 90.1-2007, and is typically a standard Packaged Terminal Air Conditioner (PTAC), as listed in the Key Assumptions for the Base Case in the Design section*. This measure will show savings only if the improved case includes air- or water-cooled chillers, heat pumps, or absorption chillers, that is, systems in which pumps are a part of the system. The assumption is that all pumps in the HVAC system will be provided with VSDs.

Compliance Guidance

To demonstrate compliance, the design team must describe the specified system and provide documentation to support the claims.

Design Stage	Post-Construction Stage
At the design stage, the following must be used to demonstrate compliance: · Mechanical and electrical layout drawings showing the entire HVAC system and highlighting the use of VSD pumps; and · Manufacturer's data sheets for VSD pumps.	At the post-construction stage, the following must be used to demonstrate compliance: · Delivery notes showing that specified VSDs have been delivered to the site; and · Manufacturer's data sheets for VSD pumps; or · Photographs of installed VSD pumps.

E22* – GROUND SOURCE HEAT PUMP

Corresponds to HTE12, RTE13, OFE14, HSE16, EDE14

Requirement Summary

If the project includes ground source heat pumps, the actual COP (coefficient of performance) of the system must be entered in the software (even if the COP is lower than the base case). The COP is used to establish the efficiency. Savings can be achieved if the Ground Source Heat Pump system achieves a COP greater than the base case, as set out in the Key Assumptions for the Base Case in the Design section.

Intention

Ground source heat pumps (GSHPs), sometimes referred to as geothermal heat pumps (GHPs), are used to heat and cool buildings by absorbing naturally existing heat from the earth. A GSHP/GHP takes advantage of the more constant below-ground temperature within the earth (soil or water) compared to the more variable outside air temperature. Below-ground temperature is warmer than the air during the winter and cooler than the air in the summer. A GHP takes advantage of this by exchanging heat with the earth through a ground heat exchanger. A GHP can reach a high COP of 3 to 5.2 on the coldest winter nights, compared to air-source heat pumps that only reach up to a 1.5 to 2.5 COP on cool days. Ground source heat pumps are a clean alternative utilizing renewable and reliable sources of energy[29].

Approach/Methodologies

EDGE uses the Coefficient of Performance (COP) to measure the efficiency of the ground source heat pump. As defined in ASHRAE, the COP is the "ratio of the rate of heat delivered to the rate of energy input, in consistent units, for a complete heat pump system, including the compressor and, if applicable, auxiliary heat, under designated operating conditions." For consistency, the ARI conditions should be used for comparison of COP values.

To achieve savings from this measure, the Ground Source Heat Pump must have a COP greater than the base case. The COP for an efficient ground source heat pump ranges between 3.6 and 5.2.

If air conditioning is not specified, any cooling load will be displayed as "virtual energy."

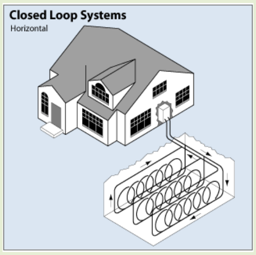
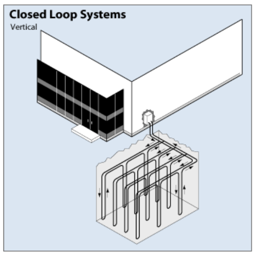
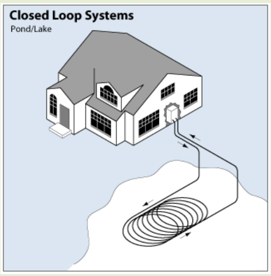
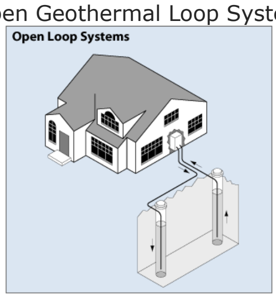
Potential Technologies/Strategies

Four major types of ground source heat pump systems (GHPs) are available. Of these four types, three systems – the horizontal, vertical, and pond systems – are closed loop systems. The fourth major type of GHP is the open loop system. A closed loop system recirculates antifreeze or water through a loop of piping that is either buried in the ground or submerged under water. A heat exchanger transfers heat between the refrigerant in the heat pump and the antifreeze/water solution. An open loop GHP system pumps water from a ground or water

29 Source: http://energy.gov/energysaver/articles/geothermal-heat-pumps and www.informedbuilding.com

source, circulates the water and then discharges it once the heat has been transferred into or out of the water. It draws fresh water instead of recirculating the same water again.

Table 38: Types of Ground Source Heat Pumps[30].

System	Geothermal Heat Pump Type	Process
Closed Loop System	Horizontal [31] 	A horizontal closed loop is usually the most cost effective for buildings with adequate land space available, in which trenches are easy to dig. This type of installation is composed of pipes that run horizontally in the ground. A slinky method is sometimes used to loop or coil the pipes along the bottom of a wide trench if space is inadequate space for a true straight horizontal system. Essentially, coiled loops are more economically and space-efficient.
Closed Loop System	Vertical 	A vertical closed loop installation is usually most cost-effective for building sites with limited amount of land space or where existing landscape is to be preserved. This type of installation is composed of pipes that run vertically beneath the ground. Holes are drilled into the ground, in which each hole contains a single loop of pipe that ranges from 30 to 100 meters deep. Vertical pipes are then inserted and connected to a heat pump within the building. This type is more expensive to install due to the drilling, but less material (piping) and land are required.
Closed Loop System	Pond/Lake 	A pond or lake closed loop system is used only if a body of water at least 2.5-meter-deep body is in close proximity to the building property. A supply line pipe runs underground from the building and connects to large, coiled pipes that are located deep beneath the water. Due to advantages of water-to-water heat transfer, a pond system is both a highly economical and efficient option for a heat pump.
Open Loop System	Open Geothermal Loop System 	An open geothermal loop system uses a well or pond to pump fresh water into and back out of the geothermal system. The water is used as the heat exchange fluid that circulates within the GHP. An abundant source of fresh clean water and a water runoff area is essential for a successful open loop system.

[30] Source: ASHRAE 90.1-2010

31 Source of all images in this table: courtesy of U.S. Department of Energy

Relationship to Other Measures

The local climate, heat gains and the internal temperatures based on the building design impact the cooling load. A more efficient system will not impact other measures, but several measures will impact the total energy use of the cooling system.

When a ground source heat pump is selected as an energy efficiency measure, the heating and/or cooling energy is reduced depending on the load on the building systems. The energy use by pumps is slightly increased due to the operation of the system.

Assumptions

The base case includes an air conditioning system based on ASHRAE 90.1-2007, which is typically a Packaged Terminal Air Conditioner (PTAC) (a ground source heat pump is not a default base case system). The efficiency (COP) value of the base case in EDGE varies depending on factors such as building area and location. The improved case COP for the ground source heat pump system varies between 3.6 and 5.2 depending on the location; if the system efficiency is different than the default value provided in EDGE, then the actual COP must be entered.

Compliance Guidance

To demonstrate compliance, the design team must describe the specified system and provide documentation to support the claims.

Design Stage	Post-Construction Stage
At the design stage, the following must be used to demonstrate compliance: · Manufacturer's data sheets for the ground source heat pump system specifying COP information; and · Mechanical and electrical layout drawings showing the location of the external loops and internal equipment and distribution for all floors.	At the post-construction stage, the following must be used to demonstrate compliance: · As-built mechanical and electrical drawings with system schematics and distribution for all floors; and · Manufacturer's data sheets for the ground source heat pump system specifying COP information; and · Photographs of the installation process of the external loops and internal equipment installed; and/or · Purchase receipts and delivery notes showing that the specified system has been delivered to the site.

E23 – RADIANT HEATING AND COOLING SYSTEM

Corresponds to OFE16

Requirement Summary

This measure can be claimed if at least 50% of the building area is served by a radiant cooling or heating system.

Intention

Reducing fan energy associated with traditional forced air cooling/ heating systems can reduce operational costs. Occupant comfort can also be improved due to reduction in wide temperature diversities, strong ventilation drafts and fan noise.

Approach/Methodologies

In EDGE, the maximum heat removal capacity of a Radiant System is taken as 50W/m^2 of ceiling area. If the cooling or heating load of the building is more than 50W/m^2, the excess load is considered as a secondary system load.

When a user selects the radiant cooling measure, the COP of the cooling system is assumed to increase by 15%. But if a DX or VRV system has been selected in the project, selecting the radiant cooling system will not show any savings. If an Absorption Chiller is selected, it is given first priority and then the radiant system.

No air flow is assumed with a radiant system, therefore, the AHU power for the radiant system is zero.

Potential Technologies/Strategies

Radiation is an effective way of heating or cooling occupants, as it involves heat transfer via infra-red waves absorbed and emitted from various surfaces. The amount of heat transfer is directly proportional to the temperature difference between the surfaces. Human thermal comfort can be achieved by designing some of the surfaces surrounding the occupants to be a bit colder (or warmer, in a heating situation) than the desired temperature. This is done typically by piping cold or hot water to "radiant panels" in the walls, ceiling or floor or in chilled beams. Radiant systems can also be standalone units. For heating, electrically operated or gas-fired panels can also be used.

Radiant systems are especially effective in spaces with large ceiling height and in non-partitioned spaces, where a traditional system will require significant forced air to condition. They are also useful in semi-open spaces, such as outdoor entrances, stadiums, etc. The radiant panels should be installed in such a way that they have a view over the occupants.

Since the radiant systems typically operate at relatively milder temperatures (less than 82ºC for heating and higher than 7ºC for cooling), the cooling/ heating plants can be much smaller. These systems do not depend on air movement for heat transfer, and the ventilation rates can be typically cut down by up to 75% just to meet the fresh air requirements. A Dedicated Outdoor Air System (DOAS), sometimes with energy recovery, can be used to provide this air.

One of the challenges to a radiant cooling system, especially in humid climates, is moisture control. If the surface temperature of the radiant panel drops below the ambient air dew point temperature, water may start condensing on the surface. This could lead to mold growth and other indoor air quality issues. The panel temperature and relative humidity of the indoor space must be properly balanced to avoid this situation.

Radiant systems also require smaller mechanical system spaces and duct sizes. Acoustic quality of the spaces is also improved due to reduction in fan noise.

Relationship to Other Measures

Effectiveness of the Radiant systems can be reduced if the building envelope (including glass) is not sufficiently insulated. In buildings with a large exterior glass area, much of the heat transfer from the radiant panels may be with exterior surfaces, instead of with the desired interior surfaces and occupants.

Assumptions

The base case for the cooling and heating system comprises of traditional forced air systems, whose efficiency can be found under the Key Assumptions on the Design tab. The efficiency is based on ASHRAE 90.1-2007.

The COP of the improved case with a radiant cooling and heating system varies according to the peak cooling load of the project building.

Compliance Guidance

To demonstrate compliance, the design team must provide documentation to support the claims.

Design Stage	Post-Construction Stage
At the design stage, the following must be used to demonstrate compliance: · Manufacturer's data sheets for the radiant cooling/ heating technology used; and · Mechanical and electrical layout drawings showing the location of the panels, and the output efficiency for system.	At the post-construction stage, the following must be used to demonstrate compliance: · As-built mechanical and electrical drawings with the location of the radiant panels, and the output efficiency of the cooling/ heating system; and · Photographs of installed equipment related to the system; or · Delivery notes showing that specified radiant technology have been delivered to the site.

E24 – SENSIBLE HEAT RECOVERY FROM EXHAUST AIR

Corresponds to HTE17, RTE19, OFE21, HSE22, EDE20

Requirement Summary

This measure can be claimed if a Sensible Heat Recovery device with at least 60% efficiency is installed in the ventilation system to reuse the heat from the exhaust air.

Intention

Recovering sensible heat from the exhaust air helps buildings to reduce fossil fuel consumption, and lower operating costs by providing useful heat for space heating and in some cases for space cooling. Buildings that use energy for heating or cooling with fresh air supply have the potential to benefit from the application of heat recovery systems for ventilation.

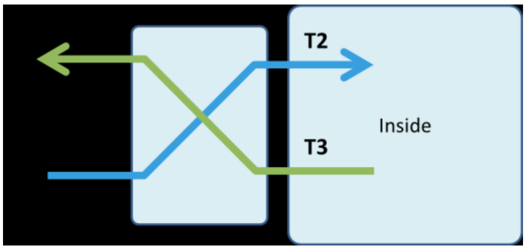
Approach/Methodologies

When buildings include an HVAC system and the main load of the building is due to space heating, installing sensible heat recovery on the ventilation system reduces energy consumption by preheating the incoming fresh air with the outgoing exhaust air. Alternatively, in cooling mode, the incoming fresh air is cooled with the exhaust air from the air-conditioned space.

To qualify, the design team must demonstrate that the HVAC system has a sensible heat recovery device on the fresh air supply system. No heat recovery system is included in the base case. EDGE uses Temperature Transfer Efficiency (TTE) as the measure of efficiency, which is either quoted by the manufacturer or can be calculated with the following formula:

Temperature Transfer Efficiency (TTE):

$$\mu t = \frac{T2 - T1}{T3 - T1}$$



Where: μ_t = Temperature Transfer Efficiency (%)

T_1 = Outside air temperature **before** heat exchanger (ºC)

T_2 = Air temperature **after** heat exchanger (ºC)

T_3 = Exhaust air temperature **before** heat exchanger (ºC)

Potential Technologies/Strategies

Heat recovery aims to collect and reuse the heat arising from a process that would otherwise be lost. In the case of sensible heat recovery in buildings, it involves transfer of energy between an exhaust airstream that preheats (winter mode) or precools (summer mode) the supply airstream. As air contains moisture, the heat contained within the air can be sensible heat (affects the temperature) or latent heat (includes water vapor). Some energy recovery devices transfer both sensible and latent heat (also called "total heat recovery"), and some only transfer sensible heat, which is the technology covered by this measure.

Sensible Heat Recovery occurs when the temperature of the cooler air stream exchanges heat with the temperature of the warmer air stream. Moisture level is not impacted unless condensation occurs.

In some areas of the building where condensation is expected, such as restaurants, spas and pools, this technology is ideal as the materials are anti-corrosive. It is also convenient for light ventilation systems as it offers low pressure drops.

Relationship to Other Measures

Sensible heat is recovered from the exhaust air, reducing the heating load in heating mode and therefore decreasing consumption in "Heating Energy." The same principle applies to the cooling load if the building is predominantly in cooling mode; then the reduction is in "Cooling Energy." The energy due to "Fans" also decreases slightly as less air is moved. However, in climates where both heating and cooling are used, savings appear in the "heating energy," but the "cooling energy" increases due to some heat trapped during midseason.

Assumptions

The HVAC systems included in the base case do not include heat recovery systems. The improved case is assumed to have a sensible heat recovery device with a Temperature Transfer Efficiency (TTE) of at least 60%. If the actual TTE value is higher or lower than 60%, the value must be entered in EDGE. It is assumed that at least 75% of all exhaust air in the building is being passed through the heat recovery system.

Compliance Guidance

To demonstrate compliance, the design team must provide documentation to support the claims.

Design Stage	Post-Construction Stage
At the design stage, the following must be used to demonstrate compliance: · Manufacturer's data sheets for the sensible heat recovery device specifying Temperature Transfer Efficiency; or · A calculation to demonstrate efficiency in case the manufacturer's data does not specify the TTE; and · Mechanical and electrical layout drawings showing the location of the heat recovery technology and indicating % of total air passing through the heat recovery system.	At the post-construction stage, the following must be used to demonstrate compliance: · As-built mechanical and electrical drawings with the location of recovery technology, if changed from design; and · Delivery notes showing that the specified recovery technology has been delivered to the site; and · Manufacturer's data sheets for the sensible heat recovery technology using the specified efficiency (TTE) if changed from design; or · Photographs of the installed heat recovery system.

E25 – HIGH EFFICIENCY CONDENSING BOILER FOR SPACE HEATING

Corresponds to HME12, HTE18, RTE21, OFE22, HSE24, EDE21

Requirement Summary

This measure can be claimed if the boiler used for delivering space heating is a condensing boiler with an annual fuel utilization efficiency greater than the base case, as set out in the Key Assumptions for the Base Case in the Design section. By default, the base case system efficiency is 80% if gas is selected as the heating fuel.

Intention

The specification of a condensing boiler for space heating can reduce the energy required to satisfy the heating load for a building, if the fuel selected for heating is gas. Condensing boilers can be up to 97% efficient.

Approach/Methodologies

To qualify, the condensing boiler must be able to demonstrate an efficiency level greater than the base case of 80%. Different methodologies can be used for demonstrating the efficiency of a condensing boiler, for example, manufacturers might quote the gross efficiency, net efficiency, seasonal efficiency, or the annual fuel utilization efficiency (AFUE), each of which uses a different methodology to calculate the percentage.

EDGE uses AFUE as the measure of efficiency as it provides the most consistent methodology. AFUE is calculated by comparing the seasonal thermal energy output to the calorific value of the fuel used. AFUE data is available from the Energy Star website at http://www.energystar.gov/productfinder/product/certified-boilers/results. If the AFUE is not available, Thermal Efficiency may be used as a proxy.

Modular systems usually use multiple boilers of the same size and type. However, where boilers with different efficiency ratings are specified, the weighted average efficiency must be calculated accounting for boiler size and the expected run time.

Potential Technologies/Strategies

An efficient boiler is one that turns as much of its fuel into useful energy as possible. Condensing boilers are most likely to achieve the highest level of efficiency. They utilize the latent heat in the waste gases' water vapor which is generated by the combustion process. Condensing boilers have a larger heat exchanger that recovers more heat and sends cooler gases up the flue. Additional heat is extracted from the water vapor from combustion; the heat extraction converts the vapor into liquid or "condensate". This condensate is removed through the drain or the flue. The types of condensing boilers available in the market are as follows:

Table 39: Types of Condensing Boiler

Type / method	Description
Heat-only boilers	· Conventional boilers · Provide both space heating and hot water · Hot water storage cylinder and cold-water top-up tanks are required, plus a loft tank for feed and expansion
System boilers	· The pump and expansion vessel are built-in, does not need a loft tank. · Designed to generate space heating and service hot water, the latter stored in a separate hot water storage tank.
Combination boilers or 'Combi'	· Combines a high-efficiency water heater and a central heating boiler in a compact unit · Heats water instantaneously on demand · Does not need a loft tank or storage cylinder · Good water pressure, as water is directly from the mains · Economical to run
Modulated control boilers	· New generation · More efficient because of the modulated controls

To achieve the best results, care must be taken not to oversize the boiler, since maximum levels of efficiency are achieved at a full load. In larger buildings with a centralized plant, like an education building, a modular system made up of an array of smaller boilers may be appropriate. Smaller boilers can be used so that when the system is under partial load, individual boilers within the array can still operate at full load.

To minimize the cost of a boiler installation, the heat loads must be minimized before sizing the system.

Relationship to Other Measures

The heat demand that the boiler is sized to supply is affected by the balance between heat gains and heat losses. Heat losses must be minimized during initial construction as the cost of improvements to the building fabric implemented during the initial construction is typically lower than the cost of installing a larger plant.

If this measure is selected, natural gas must be selected as the main fuel for space heating in the Key Assumptions for Base Case on the Design page. Only "Heating energy" is reduced with this measure.

Assumptions

The base case for the efficiency of the space-heating boiler assumes 80% efficiency. The default efficiency for the improved case is 90%, which can be overwritten. Actual efficiency must be input for the selected equipment if this measure is selected. The base case is assumed to use Electricity as the fuel for heating; if this measure is selected, the main fuel must be changed to "Natural Gas."

Compliance Guidance

To demonstrate compliance, the design team must provide the following documentation to support their claims.

Design Stage	Post-Construction Stage
At the design stage, the following must be used to demonstrate compliance: · Manufacturer's data sheet for the condensing boiler(s) specified · System schematics showing the brand and model of boiler(s), and · The calculation of the average weighted efficiency if multiple condensing boilers with different efficiencies are specified	At the post-construction stage, the following must be used to demonstrate compliance: · Updated system schematics · Photographs of the installed condensing boilers · Manufacturer's data sheet indicating AFUE for the condensing boiler(s) purchased, and · Purchase receipts and delivery notes for the condensing boilers

E26 – RECOVERY OF WASTE HEAT FROM THE GENERATOR FOR SPACE HEATING

Corresponds to HTE14, RTE15, OFE17, HSE18, EDE16

Requirement Summary

This measure can be claimed if an on-site power generator fueled by Diesel or Natural Gas provides power to the building, and a recovery technology is installed to capture the waste heat for space heating.

Intention

Recovering waste heat from power generators helps buildings to significantly reduce fossil fuel consumption, lower operating costs, and limit pollutant emissions by providing useful heat for space heating. Buildings that use fossil fuel energy for heating and that have a power generator as the main electricity source have the potential to benefit from the application of heat recovery systems.

Approach/Methodologies

If this measure is selected, the assumptions in the Key Assumptions on the Design tab must be verified. The user must select the appropriate fuel under 'Fuel Used for Electric Generator,' and input the appropriate value for '% of Electricity Generation Using [Fuel].'

Potential Technologies/Strategies

In the context of buildings, heat recovery collects and reuses the heat arising from a process that would otherwise be lost. Sometimes, the loss of this heat is intentional, such as in air conditioning, where the purpose is to remove heat from a space. But in the case of an electric generator, it typically has low efficiency and a large portion of the energy input is lost via the exhaust gases and in cooling the equipment jacket. The following image shows the different sources of waste heat and the uses of the recovered waste heat:

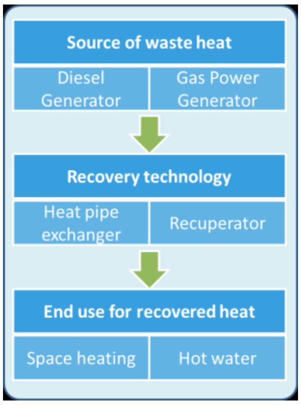


Figure 14. Typical Sources of Waste Heat and Recovery Options[32]

This waste heat can be turned into useful space heat with a recovery technology such as one of those indicated in the table below:

Table 40: Recovery technology options

Recovery Technology	Description
Thermal Energy Storage (TES)	Buffer tank where waste heat from different sources is stored and realized later to reduce the heating load during night time.
Seasonal Thermal Energy Storage (STES)	This technology is similar to TES but the heat is kept for longer periods of time, even months. Usually, the heat is stored in a bigger area where a cluster of heat-exchanger equipped boreholes is surrounded by bedrock.
Pre-heating	Simply put, waste heat can help to preheat incoming water, air and objects before they are heated to the desired temperature. This can happen in a heat exchanger, where the waste heat is mixed with the incoming air/water to increase its temperature before it enters into a boiler or heater.
Cogeneration or Combined Heat and Power (CHP) system	This is a system that reduces the waste heat used in the generation of power; however, some limitations arise from the engineering cost/efficiency of using small temperature differences on the power generation.
Recuperator	This is a type of heat exchanger with simultaneous flow of hot and cold fluids along physically separated flow paths, transferring heat between the streams.
Heat Pipe exchanger[33]	This type pf heat exchanger has vacuum-sealed tubes filled with a working fluid (heat pipes) that are used to absorb heat from a warmer surface and transfer it to a cooler surface. The working fluid inside a heat pipe evaporates at the warmer surface and then travels to the colder surface where it transfers that latent heat and turns back into a liquid phase.

[32] Source: Heat is Power Association. Trade association of Waste Heat to Power (Not-for-Profit organization)

[33] Source: Heat is Power Association. Trade association of Waste Heat to Power (Not-for -Profit organization)

Relationship to Other Measures

EDGE calculates the heating load by taking into account the local climate, heat losses and internal temperatures based on the building design. If a heating system is not specified, any heating load will be displayed as "virtual energy."

When waste heat is recovered from the generator, heating energy consumption of utility fuel is decreased. However, the energy from pumps may increase slightly due to the operation of the waste heat recovery system.

Assumptions

The default base case for the fuel of the electric generator is Diesel, as listed in the Key Assumptions for the Base Case in the Design section. The fuel can be changed to Natural Gas if that is the main fuel powering the generator. In the same section, the default assumption for the percentage of annual electricity provided by the generator is 5%. The user must input the appropriate value for '% of Electricity Generation Using [Fuel]' to update this default. Justification and documentation must be provided for these key assumptions.

Compliance Guidance

To demonstrate compliance, the design team must provide the following documentation to support their claims.

Design Stage	Post-Construction Stage
At the design stage, the following must be used to demonstrate compliance: · Manufacturer's data sheets for the electric generator specifying hours of operation and coverage of the demand; and · Manufacturer's data sheets for the recovery technology used; and · Mechanical and electrical layout drawings showing the location of the generator, the recovery technology and the output for the space heating system; and · Calculation to demonstrate that waste heat covers the percent of the demand for space heating as calculated in the EDGE software.	At the post-construction stage, the following must be used to demonstrate compliance: · As-built mechanical and electrical drawings with the location of the generator, the recovery technology and the output for the space heating system; and · Delivery notes showing that the specified electric generator and the recovery technology have been delivered to the site; and · Manufacturer's data sheets for electric generator; or · Photographs of installed external and internal equipment related to the system.

E27 – HIGH EFFICIENCY BOILER FOR WATER HEATING

Corresponds to HME13, HTE19, RTE22, HSE25, EDE22

Requirement Summary

This measure can be claimed if the boiler used for delivering hot water heating has annual fuel utilization efficiency greater than the base case, as set out in the Key Assumptions for the Base Case in the Design section. Actual efficiency must be input for the selected equipment if this measure is selected. The base case default selection for the 'Fuel used for hot water generation' is 'Electricity;' if this measure is selected, the fuel selection must be changed to 'Natural Gas' for gas boilers.

Intention

The specification of a highly efficient boiler for water heating reduces the energy required to satisfy the hot water demand for the building.

Approach/Methodologies

In order to qualify, the high efficiency boiler must be able to demonstrate efficiency greater than the base case of 80%. There are several different methodologies for calculating the efficiency of a boiler. Manufacturers might quote the gross efficiency, net efficiency, seasonal efficiency, or the annual fuel utilization efficiency (AFUE), each of which uses a different methodology to calculate the percentage.

EDGE uses AFUE as the measure of efficiency as it provides the most consistent methodology. AFUE is calculated by comparing the thermal energy output to the calorific value of the fuel used. AFUE data is available from the Energy Star website at http://www.energystar.gov/productfinder/product/certified-boilers/results.

Modular systems usually use multiple boilers of the same size and type. However, where boilers with different efficiency ratings are specified the weighted average efficiency should be calculated. The weighted efficiency takes into account the size of the boilers and the expected run time.

For tankless water heaters, if the AFUE rating is not available, Thermal Efficiency (TE) can be used instead. AFUE accounts for factors such as stand-by losses and performance at part-loads in addition to thermal efficiency but tankless water heaters do not have appreciable standby losses, so their Thermal efficiency is much closer to AFUE compared to Boilers.

Potential Technologies/Strategies

Even the most efficient boilers have a maximum efficiency around 98%, because some energy (heat) is lost via the flue gases and through the main body of the boiler itself; also, lack of maintenance can reduce a boiler's efficiency.

The following table shows a set of solutions related to hot water boilers.

Table 41: Types of High Efficiency Hot Water Boilers[34]

Type	Description
Condensing boilers	The only boilers likely to achieve efficiency level of at least 90%. They extract latent heat from the waste gases' water vapor that is generated by the combustion process. To minimize the cost of a boiler installation, hot water demand should be minimized before sizing the system.
Combi Boiler	This is a type of condensing boiler that provides both heating and hot water without needing a separate tank.
Low temperature hot water (LTHW) boilers	Produce hot water at around 90ºC, which is then distributed via pipework to a hot water storage tank. These boilers commonly run on Natural Gas, but may also be LPG.
High-efficiency boilers	These generally have lower water content, larger heat exchanger surface areas and greater insulation of the boiler shell. They are suitable to applications where a higher water temperature is required, such as kitchens, laundry and showers.
"Staged" multiple-boiler system	Reduces the amount of time in which a boiler is running at less than peak load, since only few boilers run depending on the demand. So, in the peak times more boilers are in use while during the off-peak times only the boilers to cover a small demand will be active.
Modular boiler systems	Series of boilers linked together to meet different demands; they are suitable for buildings or processes with a significant variable hot water/heating demand. Modular systems are generally composed of several identical boiler units although a mix of condensing and conventional boilers could be used.

Relationship to Other Measures

The hot water demand that the boiler is sized to supply is affected by the rate of hot water use. Hot water use should be minimized first by selecting low-flow taps in washbasins and low-flow showerheads.

If this measure is selected the main fuel for hot water must be selected as 'Natural Gas' in the key assumptions for base case on the Design page. This measure reduces both 'Water Heating' and 'Other' due to the reduction of pumping requirements for water.

Assumptions

The base case efficiency of the hot water boiler is assumed to be 80%. The default value for the efficiency of the improved case is 90%, which can be overwritten.

[34] The Carbon Trust. Low temperature hot water boilers. UK: March 2012. https://www.carbontrust.com/media/7411/ctv051_low_temperature_hot_water_boilers.pdf

Compliance Guidance

To demonstrate compliance, the design team must provide the following documentation to support their claims.

Design Stage	Post-Construction Stage
At the design stage, the following must be used to demonstrate compliance: · Manufacturer's data sheet for the boiler/s specified; and · System schematics showing the brand and model of boiler/s; and · The calculation of average weighted efficiency if multiple boilers with different efficiencies are specified.	At the post-construction stage, the following must be used to demonstrate compliance: · Updated system schematics; and · Photographs of the installed boilers; and · Manufacturer's data sheet for the boiler/s purchased; or · Purchase receipts and delivery notes for the boilers.

E28 – HEAT PUMP FOR HOT WATER

Corresponds to HME14, HTE24

Requirement Summary

This measure can be claimed if electric heat pumps are used for delivering hot water and have an efficiency greater than the base case, as set out in the Key Assumptions for the Base Case in the Design section.

Intention

Providing hot water with high efficiency will reduce fuel consumption and related carbon emissions from water heating.

Approach/Methodologies

Heat pump water heaters (HPWH) use electricity to take the heat from surrounding air and transfer it to the water in an enclosed tank. This process is similar to the heat transfer process in a refrigerator but in reverse. Heat pump water heaters can be used with dual functionality in hotels for example to cool the kitchen, laundry, or ironing area and to generate hot water.

The coefficient of performance (COP) is a measure of the heat pump's efficiency. It is determined by dividing the energy output of the heat pump by the electrical energy needed to run the heat pump, at a specific temperature. The higher the COP, the more efficient the heat pump. Typical heat pump water heaters are two to three times more efficient than standard electric water heaters.

Potential Technologies/Strategies

Type	Process
Heat Pump Water Heaters	A low-pressure liquid refrigerant is vaporized in the heat pump's evaporator and passed into the compressor. As the pressure of the refrigerant increases, so does its temperature. The heated refrigerant runs through a condenser coil within the storage tank, transferring heat to the water stored there. As the refrigerant delivers its heat to the water, it cools and condenses, and then passes through an expansion valve where the pressure is reduced and the cycle starts over.
Air-source Heat Pumps	These systems are called "integrated" units because they integrate the heating of domestic water with a house space-conditioning system. They recover heat from the air by cooling and transferring heat to domestic hot water. Water heating can be provided with high efficiency with this method. Water heating energy can be reduced by 25% to 50%.
Ground-Source Heat Pumps	In some Ground-Source Heat Pumps, a heat exchanger, sometimes called a "desuperheater," removes heat from the hot refrigerant after it leaves the compressor. Water from the home’s water heater is pumped through a coil ahead of the condenser coil, in order that some of the heat that would have been dissipated at the condenser can be used to heat water. Excess heat is always available in the summer cooling mode, and is also available in the heating mode during mild weather when the heat pump is above the balance point and not working to full capacity. Other ground-source heat pumps provide domestic hot water (DHW) on demand: the whole machine switches to providing DHW when it is required. Water heating is easier with ground-source heat pumps because the compressor is located indoors. They generally have many more hours of surplus heating capacity than required for space heating, because they have constant heating capacity. Similar to air-source heat pumps, ground-source heat pumps can reduce water heating consumption by 25% to 50%, as some have a desuperheater that uses a portion of the heat collected to preheat hot water, and also can automatically switch over to heat hot water on demand.

Relationship to Other Measures

This measure directly reduces the energy consumption for hot water. Depending on the amount of hot water usage in the building, the impact of this measure on energy use may vary.

Assumptions

The base case COP assumed for the heat pumps is 0.8 and the improved case is 3.0.

Compliance Guidance

To demonstrate compliance, the design team must provide the following documentation to support their claims.

Design Stage	Post-Construction Stage
At the design stage, the following must be used to demonstrate compliance: · Manufacturer’s data sheets for the heat pumps system specified, including the water heater’s COP information; and · For systems including more than one heat pump water heater unit, the design team must provide the average COP calculation; and · Mechanical and electrical layout drawings showing the heat pump system and the location of the water heaters.	At the post-construction stage, the following must be used to demonstrate compliance: · As-built mechanical and electrical drawings with heat pump system schematics; and · Manufacturer’s data sheets for the heat pumps system installed, including the water heater’s COP information; and · Photographs of the installed water heaters; or · Purchase receipts and delivery notes showing the heat pump’s water heaters have been delivered to the site.

E29 – PREHEAT WATER USING WASTE HEAT FROM THE GENERATOR

Corresponds to HTE21, HSE26

Requirement Summary

This measure can be claimed if waste heat is recovered from a power generator running on diesel or gas fuel, to preheat water flowing into the main hot water system of the hospital. If this measure is selected, the assumptions in the Key Assumptions on the Design tab must be verified. The user must select the appropriate fuel under 'Fuel Used for Electric Generator,' either Diesel of Natural Gas, and input the appropriate value for '% of Electricity Generation Using [Fuel].'

Intention

Recovering waste heat from power generators to preheat the water supplied to the hot water system helps buildings to significantly reduce fossil fuel consumption, lower operating costs and pollutant emissions. Hospitals that use energy for hot water and that use a power generator as a significant source of electricity can reap benefits from the use of heat recovery systems such as lower maintenance, quieter operation and higher availability of hot water, as well as reducing the energy costs and the carbon emissions from lower fuel consumption.

Approach/Methodologies

Waste heat is recovered from the power generator. The percentage of electricity provided by the generator should be marked in the Design section under Advanced Settings.

Potential Technologies/Strategies

In the context of buildings, heat recovery aims to collect and reuse the process heat waste that would otherwise be lost. Sometimes, the loss of this heat is intentional, such as in air conditioning, where the purpose is to remove heat from a space. But heat is also lost in the exhaust fumes emitted by an electric generator. Using a recovery technology, this waste heat can be turned into a useful source for hot water generation by preheating the water feeding the boiler.

Relationship to Other Measures

The use of waste heat from the generator to preheat the hot water supply reduces the load on the hot water system and shows a decrease in energy use for 'Water Heating.'

Assumptions

The default fuel for the Electric generator is Diesel, as listed in the Key Assumptions for the Base Case in the Design section. The fuel can be changed to Natural Gas if that is the fuel powering the generator. If this key assumption is changed from the default value, justification and documentation of fuel availability must be provided. Regardless of the fuel source, if the improved case uses this energy measure, it is assumed that a portion of the hot water demand is covered by the recovery of the waste heat from the generator.

Compliance Guidance

To demonstrate compliance, the design team must provide the following documentation to support their claims.

Design Stage	Post-Construction Stage
At the design stage, the following must be used to demonstrate compliance: · Manufacturer's data sheets for generator specifying hours of operation and coverage of the demand; and · Manufacturer's data sheets for the recovery technology used; and · Mechanical and electrical layout drawings showing the location of the generator, the recovery technology and the output for the water heating system; and · Calculation to demonstrate that waste heat covers % of the demand for hot water as calculated by EDGE software.	At the post-construction stage, the following must be used to demonstrate compliance: · As-built mechanical and electrical drawings with the location of the generator, the recovery technology and the output for hot water; and · Delivery notes and purchase receipts showing that specified generator and the recovery technology have been delivered to the site; and · Manufacturer's data sheets for generator specifying hours of operation and coverage of the demand; or · Photographs of installed external and internal equipment related to the system.

E30 – HEAT RECOVERY FROM GREY WATER

Corresponds to HTE22, HSE27

Requirement Summary

This measure can be claimed if a heat recovery device is installed to capture and reuse the heat from the hot water drain pipes with at least 30% efficiency. This does not include heat recovery from laundry waste water, which is a separate measure.

Intention

Recovering heat from the grey water (drain water from showers, kitchens, spa area, etc.) helps to reduce fossil fuel consumption of buildings, lower operating costs, and pollutant emissions by preheating the water for bathrooms, laundry and kitchens as part of the hot water system. Buildings that use energy for hot water have the potential to benefit from the application of heat recovery systems.

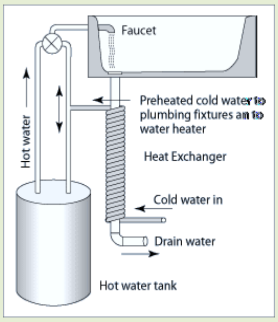
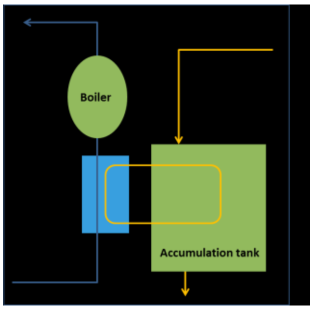
Approach/Methodologies

Buildings can benefit from technology to recover heat from grey water, as it can save energy and help decrease the design capacity of water heaters. In order to qualify, the design team must demonstrate that the Hot water system has a 'heat recovery' device. EDGE uses an efficiency of 30% for the improved case. The efficiency must be verified using manufacturer specifications.

Potential Technologies/Strategies

In the context of buildings, heat recovery aims to collect and reuse the heat arising from processes that would otherwise be lost. In this measure, heat energy is transferred from the hot waste water from showers, bath tubs, sinks, and dishwashers, etc. to the incoming cold-water pipes directly to water fixtures or to preheat the water being supplied to the hot water heater. Various commercial solutions are available for grey water heat recovery, ranging from non-storage systems (shower-only recovery) to centralized heat recovery, which connects more equipment and augments the possibilities for use of the recovered energy. The following table shows some of the solutions:

Table 42: Grey Water Heat Recovery Solutions

Types		Description
Spiral design (non-storage)		Hot water runs through a series of narrow spirals in which it is forced to spin alongside the walls of the heat recovery pipe. The cold water then comes as a counter flow in a spiral pipe swirled around the outside. This design requires small gaps (2cm) to avoid plugging. It is commonly used in residential and small hotels or hospitals. Instead of a spiral system, tubular or rectangular heat exchanger systems can also be used.
Accumulation tank (centralized)		Grey water from different sources is accumulated in a tank, which has an electrical coil (close loop) that transfers the heat to the cold water passing through the grey-water heat recovery unit outside the tank.
Parallel heat exchanger (centralized)		This is ideal for larger buildings such as hospitals, as it collects the grey water in one pipe that passes through the heat exchanger. It is similar to spiral design but used centrally rather than in each unit.

Relationship to Other Measures

The hot water demand that the boiler is sized to supply is affected by the rate of hot water use. Hot water use should be minimized first by selecting low-flow taps in washbasins and low-flow showerheads.

This measure reduces both 'Water Heating' and 'Other' due to pumping water in the system.

Assumptions

The base case assumes no heat recovery from grey water, while the improved case assumes that all the hot water discharge except laundry passes through a heat recovery system with 30% efficiency.

Compliance Guidance

To demonstrate compliance, the design team must provide documentation to support the claims.

Design Stage	Post-Construction Stage
At the design stage, the following must be used to demonstrate compliance: · Manufacturer's data sheets for grey water heat recovery device specifying recovery technology used and its efficiency (%); and · Hydraulic layout drawings showing the location of the recovery technology.	At the post-construction stage, the following must be used to demonstrate compliance: · As-built hydraulic drawings with the location of recovery technology if changed from design; and · Delivery notes and purchase receipts showing that specified recovery technology have been delivered to the site; and · Manufacturer's data sheets for grey water heat recovery device specifying recovery technology used and its efficiency (%); or · Photographs of installed equipment related to the system.

E31 – HEAT RECOVERY FROM LAUNDRY WASTE WATER

Corresponds to HTE23, HSE28

Requirement Summary

This measure can be claimed if a heat recovery device with at least 30% efficiency is installed in the hot water system to reuse the heat from the grey water of the laundry.

Intention

Recovering heat from the grey water of the laundry helps to reduce fossil fuel consumption of buildings, lower operating costs, and pollutant emissions by preheating the water that will be used in bathrooms, laundry and kitchens as part of the hot water system. Buildings that use energy for hot water have the potential to benefit from the application of heat recovery systems.

Approach/Methodologies

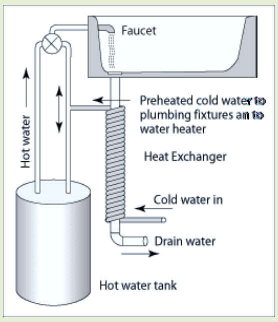
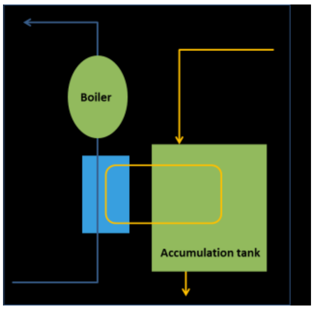
Buildings can benefit by recovering heat from the grey water of the laundry, as it can save energy and increase the capacity of water heaters.

In order to qualify, the design team must demonstrate that the hot water system has a 'heat recovery' device installed on the grey water coming from the laundry, whose efficiency must be greater than the base case (no heat recovery is included in the base case). EDGE uses Efficiency (%), which must be verified with manufacturer specifications.

Potential Technologies/Strategies

In the context of buildings, heat recovery aims to collect and reuse the heat arising from process that would otherwise be lost. In this measure, it involves transfer of energy between hot grey water coming from the laundry area (washing machines) and the incoming cold potable water. Heat from the water already used in the laundry is used to preheat the cold water entering the boiler, reducing the energy used to heat the water. Various commercial solutions are available for grey water heat recovery that ranges from non-storage systems to centralized heat recovery, which connects more equipment and augments the possibilities for use of the recovered energy. The following table shows some of the solutions:

Table 43: Grey Water Heat Recovery Solutions

Types		Description
Spiral design (non-storage)		Hot water runs through a series of narrow spirals in which it is forced to spin alongside the walls of the heat recovery pipe. The cold water then comes as a counter flow in a spiral pipe swirled around the outside. This design requires small gaps (2cm) to avoid plugging. It is commonly used in residential and small hotels or hospitals. Instead of a spiral system, tubular or rectangular heat exchanger systems can also be used.
Accumulation tank (centralized)		Grey water from the laundry is accumulated in a tank, which has an electrical coil (closed loop) that transfers the heat to the cold water passing through the grey-water heat recovery unit outside the tank.
Parallel heat exchanger (centralized)		This is ideal for larger buildings, as it collects the grey water in one pipe that passes through the heat exchanger. It is similar to spiral design but used centrally rather than in each unit.

Relationship to Other Measures

This measure can be used to reduce the size of the boiler. The size of the boiler is also affected by the rate of hot water use. Hot water use should be minimized first by selecting low-flow taps in washbasins and low-flow showerheads to reduce the boiler size.

Recovering heat from hot water waste reduces both 'Water Heating' and 'Other' due to pumping water in the system.

Assumptions

The base case assumes no heat recovery from grey water, while the improved case assumes that the hot water discharged from the laundry area passes through a heat recovery system with 30% efficiency.

Compliance Guidance

To demonstrate compliance, the design team must provide documentation to support the claims.

Design Stage	Post-Construction Stage
At the design stage, the following must be used to demonstrate compliance: · Manufacturer's data sheets for grey water heat recovery device specifying recovery technology used and its efficiency (%); and · Hydraulic layout drawings showing the location of the recovery technology installed in the laundry area.	At the post-construction stage, the following must be used to demonstrate compliance: · As-built hydraulic drawings with the location of recovery technology installed in the laundry area if changed from design stage; and · Delivery notes showing that specified recovery technology have been delivered to the site; and · Manufacturer's data sheets for grey water heat recovery device specifying recovery technology used and its efficiency (%); or · Photographs of installed internal equipment related to the system.

E32 – ENERGY SAVING LIGHT BULBS

Corresponds to HME16, HME17, HTE25, HTE26, HTE 27, RTE23, RTE24, RTE25, OFE24, OFE25, HSE29, HSE30, HSE31, EDE23, EDE24

Requirement Summary

This measure can be claimed if the light bulbs used in the project are either compact fluorescent (CFL), LED, or T5, or other types of light fixtures that achieve 90 lm/W or greater. At least 90% of the lamps must be of the efficient type.

The required spaces with efficient bulbs vary by building type. **Table 44** shows the indoor spaces that are required to have at least 90% of the lamps to be of the efficient type, by building typology. Where there is more than one row for a building type, each row represents a separate measure that can be claimed individually. This measure cannot be claimed for spaces that are not fitted with efficient lighting fixtures. For example, if an office building for lease is not fitted with lighting fixtures for tenants and there is no provision for efficient lighting in a binding lease agreement or similar provision, then this measure cannot be claimed for those spaces.

Table 44: Indoor spaces required to have efficient lighting, by Building Type

Building Type	Internal spaces that must have efficient lighting
Homes	All habitable spaces (including living rooms, dining rooms, kitchens, bathrooms, and corridors)
	Shared corridors, Common areas, Staircases
Hospitality	All guest spaces (including guest rooms, bathrooms, conference/banquet rooms, corridors, etc.)
	Back-of-the-house (including kitchens, laundry, health spa, storage area, etc.)
Retail	Sales area
	Corridors and common areas
Offices	All internal spaces (including offices, circulation area, lobby, storage, restrooms, etc.)
Hospitals	All, except Operation theaters
	Basement, car parking, and kitchen
Education	All internal spaces

Table 45 shows the outdoor spaces that are required to have at least 90% of the lamps to be of the efficient type.

Table 45: Outdoor spaces required to have efficient lighting, by Building Type

Building Type	External spaces that must have efficient lighting
Homes	Outdoor areas
Hospitality	Common outdoor spaces, such as outdoor garden
Retail	Common outdoor spaces, such as outdoor garden
Offices	Common outdoor spaces, such as outdoor garden,
Hospitals	Common outdoor spaces, such as outdoor garden
Education	Outdoor spaces of the project, such as a sports field

Intention

Efficient lamps, that produce more light with less power compared to standard incandescent bulbs, reduce the building's energy use for lighting. Due to the reduction in waste heat from efficient lamps, heat gains to the space are lowered, which in turn reduces cooling requirements. Maintenance costs are also reduced as the service life of these types of bulbs is longer than that of incandescent bulbs.

Approach/Methodologies

EDGE requires no specific efficacy for CFL, LED or T5 lamps, so the design team only needs to demonstrate that CFL, LED, or T5 lamps have been specified. Both fluorescent (e.g. CFL and T5) and LED bulbs are available with various performance specifications. Other efficient technologies are also available. If another technology is used, documentation must be provided to demonstrate that the light fixtures achieve at least 90 lm/W.

Here, lumens per watt (lm/W) is the measure of lighting efficacy used in the industry, which is the ratio of visible light output measured in lumens to the total power draw from the main electrical supply. e.g. a 40W light bulb has a total power input of 40W and a typical one may produce about 450 lumens[35]. Therefore, the efficacy of this 40 W lamp would be 450/40 or 11.25 lm/W.

Besides efficacy (lumens/watt), the key indicators are the color rendering index (CRI), color temperature (in Kelvin), and service life. CRI is a good indication of the quality of the light produced. The higher the CRI, the

[35] http://clark.com/technology/lightbulbs-watt-to-lumen-conversion-chart/

better the colors will be rendered. As color temperature is more subjective, the appropriate level will depend on the application.

EDGE does not account for lighting quality, illumination (lux or lumen) levels, or lighting layout. These should be handled by the lighting designer using local or international lighting design code requirements. Light bulbs covered by the EDGE lighting measure exclude safety and security lighting.

Potential Technologies/Strategies

The following table explains the different technologies for the recommended energy saving light bulbs:

Table 46: Description of technologies (lamp types)

Lamp Type	Description
Compact fluorescent lamps (CFLs)	CFLs are available for most light fittings as a direct replacement for incandescent bulbs. CFLs use a fluorescent tube that has been folded into the shape of the incandescent bulb they have been designed to replace. In comparison to incandescent bulbs, CFLs can last as much as 15 times longer. It should be noted that the service life can be reduced by frequent switching, so CFLs are not always appropriate where lights will be turned on and off frequently. CFLs use only a fraction of the energy of their incandescent alternatives and therefore produce less heat. As with normal fluorescent lamps, CFLs require ballasts in order to operate. Older lamps use magnetic ballasts, but these have largely been replaced with electronic ballasts that operate at a high frequency. Although the efficacy is not affected, electronic ballasts have reduced warm-up times and flickering, which were issues with the earlier CFLs.
Light emitting diode (LED)	LED technology has evolved quickly and there are LED lamps available for most light fittings, and in different color temperatures ranging from warm white to daylight. The efficacy levels of LEDs are much higher than CFLs. The service life of LED lamps can be as much as two to three times the longest life of any available compact fluorescent lamp, and is not affected by frequent on/off cycles. Over the last few years, the performance of LED lamps has improved greatly while prices have dropped sharply, and they are now highly cost-effective.
T5 Lamps	The name of these fluorescent tubes refers to their shape (tubular) and diameter (5 units measured in 1/8s of an inch). T5s have a miniature G5 bi-pin base with 5mm spacing, while T8s and T12s have a G13 bi-pin base with 13mm spacing. Although T8/T12 to T5 conversion kits are available, dedicated T5 luminaires should be specified in new construction projects, as using ballasts designed for T8s and T12s could reduce the service life of T5s.

Although the efficacy of bulbs from different manufacturers will differ, **Table 47** gives an approximate range of efficacies that can be expected for different bulb technologies.

Table 47: Typical range of efficacies for different lamp types[36]

Lamp Type	Typical Range of Efficacy (Lumens/Watt)	Rated lifetime (hours)
Incandescent – Tungsten Filament	10-19	750-2,500
Halogen lamp	14-20	2,000-3,500
Tubular Fluorescent	25-92	6,000-20,000
Compact Fluorescent	40-70	10,000
High Pressure Sodium	50-124	29,000
Metal Halide	50-115	3,000-20,000
Light Emitting Diode (LED)	50-100	15,000-50,000

Relationship to Other Measures

Using more efficient bulbs reduces the heat gain from lighting, thereby reducing cooling loads. Heating loads may increase in a heating dominated climate. A related measure is daylighting; better daylight design can reduce the need for artificial lighting during the daylit hours.

Assumptions

The default assumption for the base case is that the lighting is a mixture of standard incandescent lamps and efficient lamps. The improved lighting density assumes that at least 90% lamps in the improved case are not incandescent, but of a more efficient type. The assumed lighting load (in Watts/m²) for each area in both cases (baseline and improved) is available in Appendix 2.

[36] Source: https://www.eia.gov/consumption/commercial/reports/2012/lighting/ Data from the 2011 Buildings Energy Data Book, Table 5.6.9, Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy

Compliance Guidance

To demonstrate compliance, the design team must provide the following documentation to support their claims.

Design Stage	Post-Construction Stage
At the design stage, the following must be used to demonstrate compliance: · Lighting schedule listing type and number of bulbs specified; · Electrical layout drawings showing the location and type of all installed bulbs; · Manufacturer's data sheets ***or*** calculations showing that fixtures that are not CFL, LED or T5 meet the 90 lm/W threshold.	At the post-construction stage, the following must be used to demonstrate compliance: · As-built electrical drawings with the lighting layout if changed from design; · Manufacturer's data sheets *and* calculations showing that fixtures that are not CFL, LED or T5 meet the 90 lm/W threshold. · Photographs of the lighting installation. It is not necessary to take photos of every single installed lamp, but the auditor must be convinced that a reasonable proportion has been checked and verified; or · Purchase receipts and delivery notes for lamps

E33 – LIGHTING CONTROLS

Corresponds to HME18, HTE28, HTE29, RTE26, OFE26, OFE27, OFE28, OFE29, HSE32, HSE33, HSE34, EDE25, EDE26, EDE27, EDE28

Requirement Summary

This measure can be claimed if lighting in all the required rooms are controlled using technologies such as occupancy sensors, timer controls, or light sensors. **Table 48** shows the spaces and the controls required to claim this measure, depending on the building type. Each row represents a measure that can be claimed separately in the EDGE App.

Table 48: Lighting Control Requirements by Building Type

Building Type	Spaces required to have lighting controls	Control type required
Homes	Shared corridors, Common areas, Staircases, and Outdoor areas	Photoelectric switching or dimming, occupancy sensors, or timer controls
Hospitality	Corridors, common areas, staircases, and outdoor areas	Photoelectric switching or dimming, occupancy sensors, or timer controls
	Bathrooms	Occupancy sensors
Retail	Bathrooms	Occupancy sensors
Offices	Corridors, Staircases	Daylighting controls
	Bathrooms, Conference Rooms, and Closed Cabins	Occupancy Sensors
	Open Offices	Occupancy Sensors
	All internal spaces with access to natural light	Daylight Photoelectric Sensors
Hospitals	Corridors	Daylighting controls
	Bathrooms	Occupancy Sensors
	All internal spaces with access to natural light	Daylight Photoelectric Sensors
Education	Bathrooms	Occupancy Sensors
	Classrooms	Occupancy Sensors

	Corridors	Occupancy Sensors
	All internal spaces with access to natural light	Daylight Photoelectric Sensors

Intention

By installing lighting controls in rooms, lighting usage is reduced use. Lighting use may be reduced by using occupancy sensors to reduce the possibility for lights to be left on when the room is unoccupied, or by using photoelectric sensors when sufficient natural light is available. Reduced lighting use leads to a reduction in energy consumption.

Approach/Methodologies

No calculations are involved in the assessment of this measure. To claim that it has been achieved, the lighting in all the required rooms must be connected to lighting controls. In the case of lighting controls for daylighting, all ambient lighting in "daylight zones" which have access to exterior windows, or skylights, must be connected to an automatic daylight control system using photosensors. Daylight zones next to windows are defined as the perimeter space near a window with a depth = 1.5 x head height of the window from the floor.

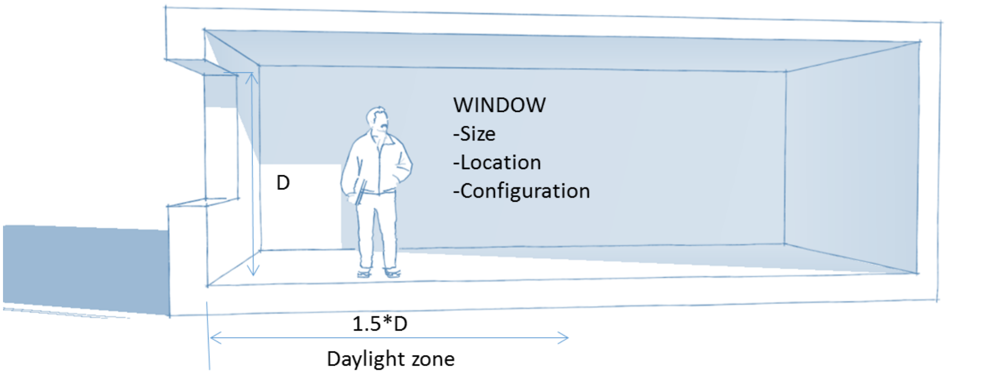


Figure 15. Daylight zone configuration

Potential Technologies/Strategies

Controlling artificial lighting in occupied areas reduces energy consumption. Occupancy sensor controls are effective in saving lighting energy in spaces that have varying occupancy over the working hours. If many of the spaces in a building are expected to be unoccupied during some hours of the day, such as a conference room or a classroom, this measure may be considered.

Selection of the type of sensor and its location is critical for this measure. The sensor should be situated such that it can "see" all the occupants in the room. If the room is small enough, this could be done by placing the sensor in one corner of the room near the ceiling. For larger rooms, multiple sensors may be used.

Table 49 lists various types of controls with their pros and cons. Typically, occupancy sensors are used to control ambient lighting only. However, task lights, such as table lamps and under-cabinet lights may also be controlled by automatic sensors. Individual power strips equipped with in-built occupancy sensors may be used for this purpose.

Table 49: Types of controls for lighting and other equipment

Type	Description
Timer Controls	The two types of timer controls are: time delay switches and actual timer controls. Time delay switches are manually switched on and then automatically switch off after a set time, which can be adjusted. Time delay or time lag switches can either be mechanical (pneumatic time delay) where the lighting requirement is less than 30 minutes, or they can be electronic, which can be programmed to provide a longer delay. A time delay switch is most appropriate in spaces where lighting is only used for short periods of time, such as bathrooms in common areas or rarely-used corridors. Timer controls use a built-in clock function to switch on and off at preset times. They can either be used to switch lights off when the lighting is unlikely to be required (such as security lighting during daylight hours), or to switch lights on at a set time (such as decorative lighting). Timer controls should always be fitted with a manual override so that out-of-hours use is still possible if required.
Occupancy or Presence Detectors	Occupancy or presence detectors can be used to switch lights on when movement or presence is detected and switch them off again when no movement or presence is detected. These may be used in areas of infrequent use by staff and public. Some technologies are as follows: • *High frequency ultrasonic sensors*, detect occupancy by emitting a high-frequency signal, which they receive back as a reflected signal using the Doppler effect, and interpret change in frequency as motion in the space[37]. They can work around obstructions. These are first generation occupancy sensors and not very reliable as they get triggered by any movement including undesirable triggers. • *Passive Infrared Sensors (PIR),* detect human body temperature by sending out infrared beams to detect temperature differences. These are an advancement on ultrasonic sensors. However, PIRs do not always work well in very hot climates, as the background temperature is similar to human body temperature. They also require a direct line of sight[38]. • *Microphonics sensors*, utilize a microphone inside of the sensor to hear sounds that indicate occupancy. They can learn to ignore background noise such as air conditioners and do not rely on line of sight. So they are especially useful in rooms with obstructions such as bathrooms with stalls. • *Dual technology sensors,* use a combination of technologies described above to reduce the chances of false-on and false-off. As each type of presence-detecting technology has different limitations, many controls use a combination of the three technologies.
Daylight Sensors	Daylight sensors can be used to switch lights on or off, alone or in conjunction with dimmers. Daylight sensors sense the availability of daylight and can switch lights off or trigger lighting dimmers to produce reduced lighting levels to maintain a comfortable level of light.

[37] Source: http://www.ecmweb.com/lighting-amp-control/occupancy-sensors-101

[38] Source: Occupancy Sensor Technologies by Acuity Brands (2016)

Natural light is amply available during daytime hours in most climates. Typically, just 1%-5% of the diffused exterior lighting available outside the building is sufficient to light up the interiors to the desired light levels. An intelligent daylight design has the following features:

- Optimum glass area: Windows need to be appropriately sized to allow sufficient diffused light into the space, without causing too much heat transfer. Especially in warm climates, a large amount of window area (above 40% window to wall ratio) may result in excessive cooling load, which may outweigh any benefits gained through daylighting control. Location and orientation of glass is also critical. South and North facing glass are more appropriate as they can be shaded easily and do not cause as much glare. Also, windows that are higher on the wall are more efficient in allowing diffused light deeper into the space.

- Suitable sun shading: Diffused sunlight is more desirable for daylighting. Direct sunlight should be avoided into regularly occupied spaces, as it causes glare and overheating. Windows on the south and north façades should be shaded with horizontal overhangs, whose depth is dictated by the latitude of the building location. In tropical countries, the required depth of horizontal shading is quite small. East and west windows should be avoided as much as possible. If provided, they should be equipped with vertical shading or full glass shading.

- Appropriate glass product: In climates where solar heat is undesirable, glass with low Solar Heat Gain Coefficient (SHGC) should be used. SHGC is the proportion of solar heat that the glass allows to pass through to the interior space. At the same time, care should be taken that the Visible Light Transmittance (VLT) of the product is not too low, as it will reduce the amount of usable light entering the space.

- Automated daylight control system: Energy is saved through daylighting only if the electric lights are switched off. It is desirable that the switching be done through automated controls to avoid missed opportunities. The two commonly used daylighting control types are Stepped and Continuous Dimming. A Stepped system turns off some lamps in the space when enough natural light is available by the photo sensor. A Continuous Dimming system dims down all lights to maintain the desirable light levels. Stepped controls are less expensive, while the Continuous Dimming system offers more savings. For both systems, the photo sensor should be appropriately located and calibrated to be effective.

Relationship to Other Measures

Lighting controls can reduce the amount of energy used by lighting in rooms, therefore the more efficient the light bulbs are, the less impact the automated controls will have. However, when using controls with energy efficient lighting, one should make sure to choose the correct light bulbs, which are not impacted by the increased switching or dimming.

As lighting controls help to reduce unnecessary use of lighting which produces heat, cooling loads are reduced. Both "Lighting" and "Cooling Energy" are reduced in the energy graph, while "Heating Energy" is increased.

The amount of savings achieved with a daylighting measure will be affected by the Window to Wall Ratio entered in the WWR measure.

Assumptions

The base case assumption is that manual controls will be used for the control of all lighting. The improved case assumes that these spaces will have technology to reduce lighting usage by a certain amount. The assumed percentage reduction in lighting for each area for various building types is available in Appendix 2.

In the case of daylighting, the improved case assumes that all occupied perimeter spaces with windows will have automated daylight controls that will switch off electric lights during some part of the day. The amount of savings will depend on the geographical location and building geometry defined in the "Building Orientation" section of the Design tab.

Compliance Guidance

Design Stage	Post-Construction Stage
At the design stage, the following must be used to demonstrate compliance: · Electrical layout drawings showing the sensors, highlighting the location of the sensors; and · Specifications of the sensors from the manufacturer.	At the post-construction stage, the following must be used to demonstrate compliance: · Photographs of sensors and controls. It is not necessary to take photos of every sensor, but the auditor must be convinced that a reasonable proportion has been checked and verified; and · As-built electrical layout drawings showing the location of the sensors if changed from design; or · Purchase receipts and delivery notes for sensors.

E34 – SKYLIGHT(S) TO PROVIDE DAYLIGHT TO 50% OF TOP FLOOR AREA

Corresponds to RTE30

Requirement Summary

This measure can be claimed if the top floor of a building utilizes natural daylight from skylight(s) to light up the top floor of the interior, reducing the use of artificial lighting during daytime hours.

Intention

The intent of this measure is to reduce the use of electricity for artificial lighting by using natural daylight. The use of daylight for lighting interior spaces requires only a part of the roof to be transparent, and can save significant amounts of electricity usage for lighting, especially in spaces that are used mostly in the daytime.

Approach/Methodologies

The skylight(s) must be well distributed to provide maximum daylight penetration in the building. The skylight(s) may be horizontal or vertical (also called roof monitor).

To claim this measure, the design team must demonstrate that transparent elements in the roof allow sufficient daylight to achieve the required lighting level in the interior of the space of the top floor area, and that the lights in this area are equipped with dimming or shut-off controls such as daylight-responsive controls.

The "Daylight Zone" claimed under each type of skylight must comply with the guidelines accompanied by the figures below.

1. The Daylight Zone of a skylight shall extend in both horizontal directions along the floor beyond the edge of the skylight to the lesser of (i) 0.7 x the ceiling height, or (ii) the nearest obstruction that is 0.7 times the ceiling height or more, as indicated in **Figure 16**.
    a. An obstruction *less* than 0.7 x the ceiling height (CH) may be ignored
    b. An obstruction up to 0.7 x CH in height that is *closer* than 0.7 x (CH minus the obstruction height (OH)) may be ignored[39]
2. In the case of multiple skylights, the floor areas under the skylights which are being counted as Daylight Zone areas must not overlap.
3. The lighting in each Daylight Zone area must be controlled with either manual or daylight-responsive controls. Controls or calibration mechanisms must be readily accessible, and may serve all light fixtures, alternate fixtures or individual fixtures in a zone. Dimmable controls must be capable of dimming to 15% of light output or lower and be capable of complete shut-off.
   Exceptions:

[39] Adapted from: (1) ASHRAE Standard 90.1-2015 and (2) International Energy Conservation Code 2015, Section C405.2 Lighting Controls

a. Areas with less than 6.5 Watts/m^2 of general lighting may not be controlled
b. Areas designated as security or emergency areas that are required to be continuously lighted
c. Interior exit stairways, interior exit ramps and exit passageways
d. Emergency egress lighting that is normally off
e. Display/accent lighting must have dedicated controls independent of the general lighting controls

Design Guidance

Sunlight access must not be blocked for > 1500 hours in a year between 8 a.m. and 4 p.m.

One method to verify the adequacy of the daylighting system is to calculate the product of the visible transmittance (VT) of the skylight and the area of the skylight (rough opening), divided by the area of the Daylight Zone. The result must be no less than 0.008.

$$VT \times \frac{Area\ of\ Skylight}{Area\ of\ Daylight\ Zone} \geq 0.008$$

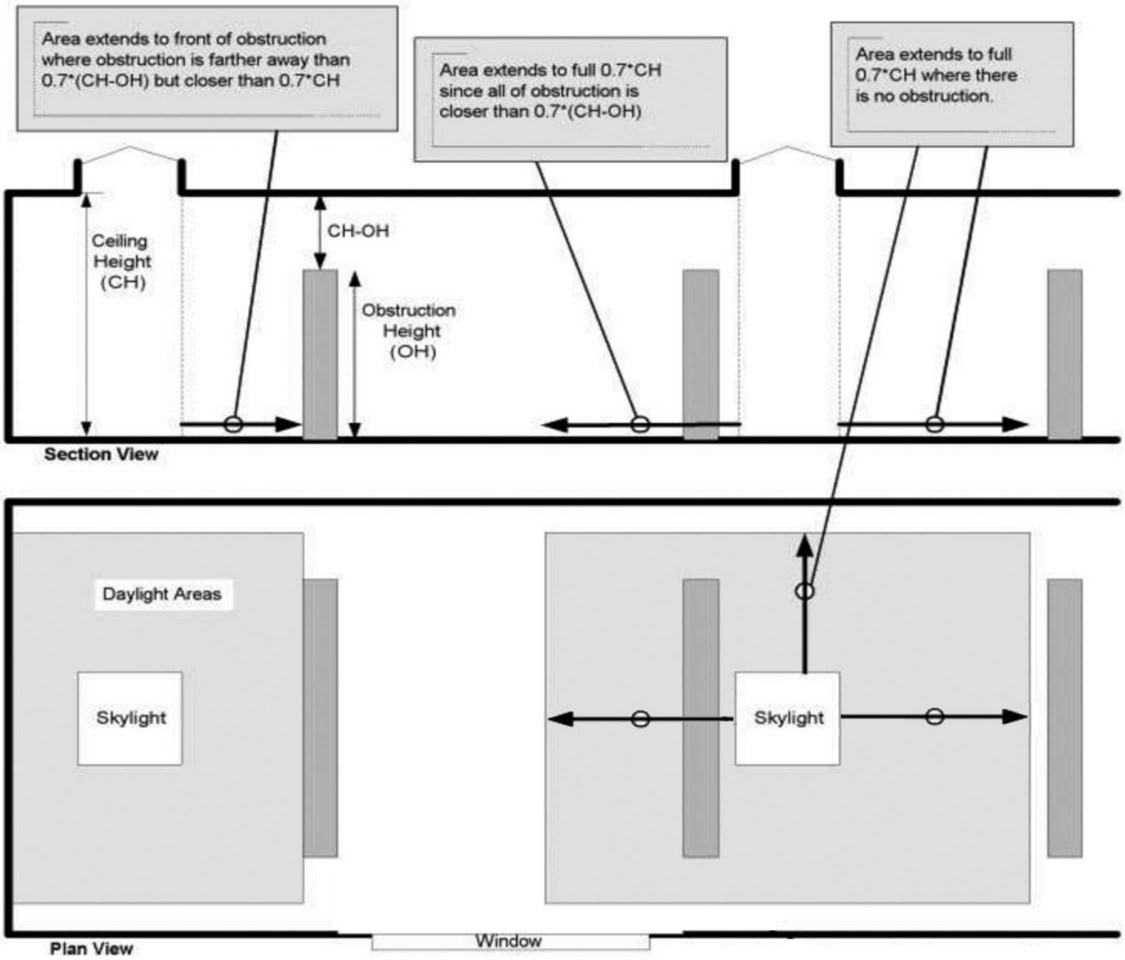


Figure 16. Daylight zone under roof skylights

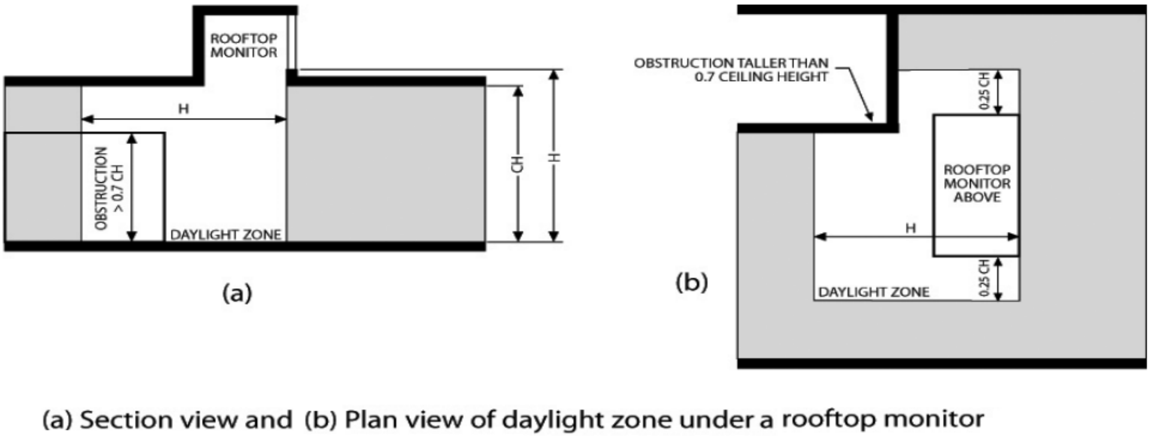


Figure 17. Daylight zone under a vertical skylight (roof monitor) with a flat top

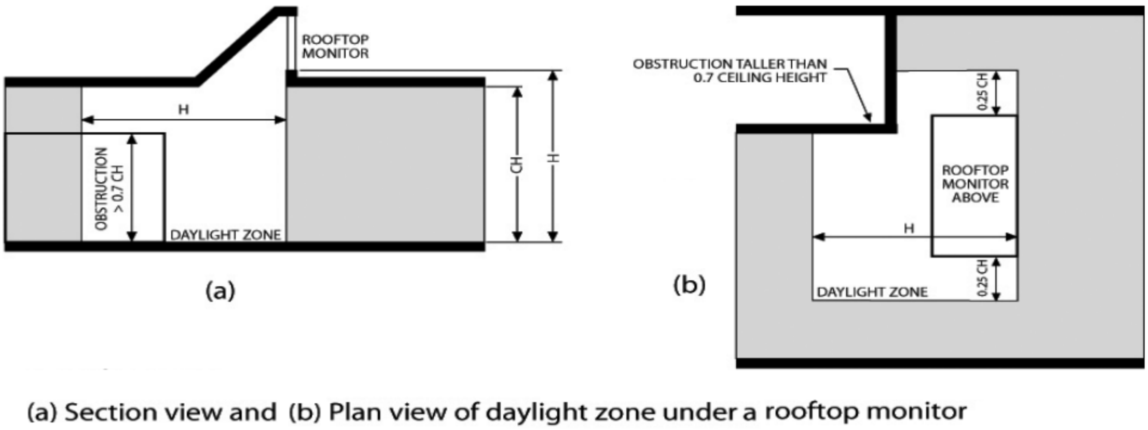


Figure 18. Daylight zone under a vertical skylight (roof monitor) with a sloping top

Potential Technologies/Strategies

Natural daylight can be introduced into the top floor using windows in the roof, that is, skylights. Glass skylights are typically used, but daylight can also be introduced through other transparent or translucent materials such as translucent insulation panels.

Relationship to Other Measures

The use of skylights will impact the heat gain through a roof which will impact the energy use for space conditioning. The area of skylights and their thermal properties (the Solar Heat Gain Coefficient or SHGC and the U-value) must be optimized to avoid excessive heat gain. Reduction in electricity usage for artificial lighting by using skylights must be balanced with the potential increase in cooling energy use.

Assumptions

The base case assumes no skylights in the building. When this measure is selected, the improved case with skylights assumes that a default area of 50% of the top floor is a Daylight Zone served by skylights, with a default Solar Heat Gain Coefficient (SHGC) of 0.35 and a U-value of 1.7 W/m^2.K. Selecting the measure also reveals the editable fields for (1) the area of the Daylight Zone (represented as a percentage of the top floor area) labelled as "% Day Lit Area," (2) SHGC of the fenestration, and (3) U-value of the fenestration.

Compliance Guidance

Design Stage	Post-Construction Stage
At the design stage, the following must be used to demonstrate compliance: · Building plans and sections showing the skylight(s) and obstructions in the daylight zones; and · Lighting plans showing the lighting controls in the Daylight Zones.	At the post-construction stage, the following must be used to demonstrate compliance: · Photographs of the installed skylight(s); and · Photographs of the daylit area; and/or · As-built documentation of the lighting control system

E35 – VARIABLE SPEED HOODS WITH AUTOMATED FAN CONTROLS

Corresponds to HTE20

Requirement Summary

This measure can be claimed if the exhaust fans in the kitchen hoods have Variable Speed Drives (VSD) installed.

Intention

By specifying VSD on the fans of exhaust hoods in kitchens, energy consumption and related utility cost are reduced. Also, the lifetime of the system components is increased and less maintenance is needed.

Approach/Methodologies

Standard exhaust hoods in commercial kitchens typically operate at a fixed speed designed for maximum (peak) load. However, that peak ventilation is not always required. Smart controlled hoods have VSDs installed on the fans, which are controlled by a temperature sensor, therefore reducing energy consumption between 20% and 50% (see Figure 19 below), because the VSDs control and regulate the fan speeds depending on the temperature of the cooking surface. Lowering fan speed reduces noise levels as well as maintenance costs, while the life of kitchen equipment could be extended.

To claim this measure, the design team must demonstrate that VSDs with temperature control are installed within the exhaust hoods of the kitchen.

Figure 19. Savings with use of VSD on kitchen hoods[40]

[40] Schneider Electric, *Leading the Way to Energy Savings*, August 2009, p. 33, Retrieved on April 11, 2018 from http://www2.schneider-electric.com/documents/designers/SOLTED109025EN.pdf

Potential Technologies/Strategies

According to the US Environmental Protection Agency (EPA), kitchens in commercial premises consume 2.5 times more energy than any other commercial space, of which only 40% is used in food preparation and storage; much of the wasted energy is dispersed into the kitchen[41]. Kitchens in hotels mostly have grills, ovens and fryers, which require high levels of ventilation and therefore consume large amounts of electricity. In many cases, this high consumption is due to the fans in the kitchen hoods running constantly at maximum speed regardless of the requirements. Lowering the speed of fans and controlling the time of use with sensors (air temperature) will result in energy reduction.

The fans can be electronically controlled with the Variable Speed Drivers (VSD), a piece of equipment that regulates the speed of the fan according to air temperature, which is detected by a sensor installed inside the exhaust hood. It can determine if the cooking surface temperature rises, therefore the fan speed increases to compensate, but if the air is cooler, then, the fan runs more slowly. VSD offer an improved system reliability and process control, as well as result in energy savings.

Relationship to Other Measures

Energy reduction due to kitchen equipment is expected by automated control hoods which will be reflected in the 'Catering Energy' portion of the energy chart, and its contribution is purely related to energy.

Assumptions

The base case assumes conventional exhaust hoods in kitchens, while the improved case assumes that all the exhaust hoods are provided with VSDs that control the fan speed according to the temperature at the cooking surface.

[41] US EPA data quoted by Carbon Trust UK, *Energy Efficiency in the Kitchen*, March 27, 2010, Retrieved on April 11, 2018 from the Green Hotelier webpage http://www.greenhotelier.org/our-themes/energy-efficiency-in-the-kitchen/

Compliance Guidance

To demonstrate compliance, the design team must provide documentation to support the claims.

Design Stage	Post-Construction Stage
At the design stage, the following must be used to demonstrate compliance: · Electric drawings/specifications of automated control hood including make and model of the VSD control; and · Manufacturer's specification of the automated control hood; and/or · For systems including more than one exhaust hood, the design team must ensure that all fans are provided with VSDs.	At the post-construction stage, the following must be used to demonstrate compliance: · As-built electrical drawings detailing the automated control hood installed; and · Purchase receipt for the automated control hood; or · Photographs of installed VSDs in the exhaust hoods of the kitchen.

E36 – ENERGY EFFICIENT REFRIGERATORS AND CLOTHES WASHING MACHINES

Corresponds to HME15

Requirement Summary

This measure can be claimed if the refrigerators and clothes washing machines installed are energy efficient. This can be demonstrated by purchasing refrigerators and clothes washing machines that achieve recognized appliance ratings as described in the Approach/Methodologies section below. This measure cannot be claimed if homes are not fitted with efficient refrigerators and clothes washing machines at the time of certification, and there is no binding agreement in place to ensure that they will be installed at a later date.

Intention

Minimize the energy consumed by refrigerators and clothes washing machines installed in a home.

Approach/Methodologies

EDGE uses the following recognized appliance rating systems, but is not necessarily limited to:

- Energy Star rated; or
- Minimum 'A' rating under the EU Energy Efficiency Labelling Scheme; or
- Equivalent level in a comparable rating scheme[42] to the ones above

Potential Technologies/Strategies

Appliance	Overview	Key Features for Efficiency
Refrigerators  	After heating and cooling, refrigeration appliances are the biggest energy consumption in a household, as they	An efficient refrigerator should: · Be small. Consider refrigerators with a capacity of 14 to 20 cubic feet (>4 people). · Have a high efficiency compressor (350kWh/year or less). · A model with the freezer on top (not a bottom-mounted freezer or side-by-side model). · Not have an automatic ice-maker and/or through-the-door ice dispenser. · Have automatic moisture control rather than an "anti-sweat" heater.

[42] If other rating schemes are used, evidence describing how the refrigerator or clothes washing machine meets or exceeds the equivalent requirements under the Energy Star or EU labelling scheme must be submitted.

are working continuously.

Clothes Washing Machines

About 60% of the energy used by a washing machine goes towards water heating; therefore, models that use less water also use less energy.

An efficient clothes washing machine should:

- Be the right size for the house.
- Have several wash cycles.
- Have improved water filtration.
- Have a dryer with a moisture sensor.
- Have a model with a high Modified Energy Factor (MEF) and a low Water Factor (WF).

The way the occupants use the appliances also influences energy performance. It is important to provide users with guidelines outlining the benefits of these appliances, and the best way to achieve maximum efficiency.

Relationship to Other Measures

Energy reduction due to appliances is expected by both energy efficient refrigerators and clothes washing machines. Clothes washing machines also show reductions in energy due to hot water as well as lower water consumption.

Assumptions

The base case assumes standard refrigerators and clothes washing machines, while the improved case is 5% to 10% more efficient.

Compliance Guidance

Design Stage	Post-Construction Stage
At the design stage, the following must be used to demonstrate compliance: · Summary list of the refrigerators and clothes washing machines to be installed in the building, including quantity, energy use, and proof of certification by *Energy Star*, *EU Energy Efficiency Labeling Scheme,* or equivalent; or · Specifications from the manufactured detailing energy use.	At the post-construction stage, the following must be used to demonstrate compliance: · Updated summary list of refrigerators and clothes washers installed in the building including quantity, manufacturer, and model; and · Proof of certification by *Energy Star*, *EU Energy Efficiency Labeling Scheme,* or equivalent; or · Specifications from the manufactured detailing energy use.

E37 – HIGHER EFFICIENCY REFRIGERATED CASES

Corresponds to RTE27

Requirement Summary

This measure can be claimed if the refrigerated cases, and any other fridge or refrigerator installed are energy efficient. This can be demonstrated by purchasing refrigerated cases, fridges and refrigerators that achieve recognized appliance ratings as described in the Approach/Methodologies section (below).

Intention

Minimize the energy consumed by refrigeration equipment installed in the buildings, such as supermarkets and small food retail, to reduce the operational costs and increase the reputation of the retailer.

Approach/Methodologies

EDGE uses the following recognized appliance rating systems, but is not limited to:

- Energy Star rated - Commercial Food Service (CFS) equipment, which are up to 40% more efficient than standard ones; or
- Minimum 'A' rating under the EU Energy Efficiency Labelling Scheme [43]; which will be mandatory in 2016 for commercial refrigeration cabinets (draft versions are currently available); or
- Listed in the Energy Technology Product List (ETL)[44]; or
- Equivalent level in a comparable rating scheme [45] to the ones above.

The energy chart shows reduction in 'Refrigeration'.

Potential Technologies/Strategies

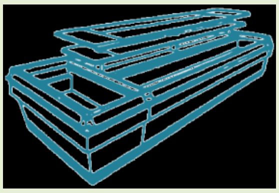
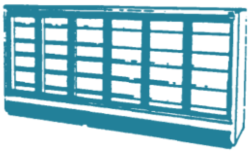
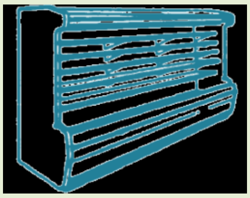
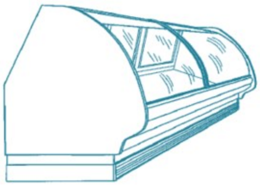
Refrigerated cases are mostly used in supermarkets and small food retail, where up to half of the energy consumption is dedicated to the refrigeration systems (display cases and storage coolers). Four main categories of refrigerated cases are shown in the table below:

[43] The scheme will be launched in July 2016. Draft versions can be used

[44] Energy Technology List (ETL) is the UK government-managed list of energy-efficient plant and machinery. ETL website: https://etl.decc.gov.uk/etl/site/etl.html

[45] If other rating schemes are used, evidence describing how the refrigerated cases, fridges and refrigerators meets or exceeds the equivalent requirements under the Energy Star or EU labelling scheme or ETL list must be submitted.

Table 50: Types of refrigerated cases

Type of refrigerated cases		Use	Key Features for Efficiency
Tub or Island		Storage and display of frozen foods and meats.	· Operate at a very uniform temperature and less amount of refrigeration per unit area. · It has low storage volume per unit area used.
Glass door reach-in		Supermarkets, primarily for frozen foods	· Ability to contain the cold refrigerated air, which reduces the "cold aisle" problem. · Less refrigeration loads. · EEMs for this type are anti-sweat heaters in the doors to prevent fogging and decreased visibility of the product.
Open-front multi-deck			· Possesses the largest storage volume per unit area, because of the use of an upright cabinet and shelves. · high Refrigeration requirements for multi-deck cases, including latent load from ambient air. · Recommended EEMs for this type are air curtains.
Single-deck or service		Display of fresh meat products.	· Equipped with sliding doors in the back for the staff and a glass front to show the products to customers. · Commonly seen in the deli and meat departments of supermarkets.

The energy use of the cases described above is related to the refrigeration load, the sources of which are:

- **Infiltration:** Moist and warm air from the ambient pass through the open front of the cases. Energy efficiency measures (EEMs) include air curtains or glass doors, which are detailed in **Table 51**;
- **Conduction:** Case panels and walls allow heat to be conducted to the interior of the case;
- **Thermal radiation** from the ambient surfaces to the product and display case interior; and
- **Internal heat gains:** generated by the lights, evaporator fans, periodic defrosts, and anti-sweat heaters.

To reduce this load various energy efficiency measures (EEMs) could be applied to the refrigerated cases, which result in the reduction of the refrigeration load and therefore energy savings of the retail units. These EEMs are explained in the table below:

Table 51: Efficiency measures for Refrigerated cases

Technologies / controls	Potential saving (refrigeration) energy [46]	Application	Benefits / Key Features for Efficiency [47]
Glass doors	Up to 50%	· Chilled and frozen multi-decks	· Better performance to medium temperature cases. · Special Polymer doors reduce the need for thermal glass.
Strip Curtains and Air curtains	30%	· Chilled multi-decks · Well freezers	· Reduced infiltration of ambient air and humidity into the display case.
Night blinds or night covers	20%	· Chilled multi-decks · Well freezers	· Out-of-hours usage to reduce heat gain from ambient temperature
Multideck Air Curtain Optimisation Technology	17%	· Chilled multi-decks	· Cost savings from reduced energy consumption · Low cost and fast payback within two years · Easy to install and minimal maintenance · Warmer shopping aisles for improved consumer experience
Defrost optimization	20%	· Freezers	· Need of defrost controls that triggers defrost only when needed
Interior Lighting	5 - 12%	· All types	· Energy-efficient lights: LED lighting or T8 lamps · Electronic Ballasts
Efficient Modular / Multi Evaporator coil	10%	· All cabinets · Mainly freezers	· Defrost system to be installed with multi-evaporator · Enhance heat transfer · Evaporator coil to operate at a close temperature difference (TD). · Efficient coil: evaporation occurs over the greatest length of coil tubing, which maintains a reasonable evaporator size. · Use of electronic expansion valves.
High efficiency compressors and fans (evaporator or motors)	9%	· All cabinets with forced air convection	· Reduce both refrigeration load and direct energy consumption, as coil defrost is less needed. · Use of electronically commutated motor (ECM) · Use of variable-speed drive (VSD), which enables the coil to be held constant throughout the time between defrosts, and to reduce defrost time/cycle.
Electronic Commutated Motors (ECM)	2 -8 %	· Evaporator: All cabinets with forced air convection · Condenser: All integrals and remote system	· 2% for reach-in freezers · 7% for reach-in refrigerators · 8% for (grocery) display cases
Thicker Insulation	4 - 6%	· All - primarily frozen	· Insulation such as Vacuum Insulated Panels (VIPs) helps cut conduction heating of the cases.
Non-electric Anti-sweat heater controls	3 - 6%	· Freezers cabinets	· Reduce energy consumption as load is decreased.
High efficiency Liquid Suction Heat Exchanger (LSHX)	3%	· All cabinets	· Provides sub-cooling of liquid refrigerant through useful superheat. · Allows the evaporator coil to operate with low superheat at the evaporator outlet.

[46] Potential supermarket energy efficiency options

[47] Investigation of Energy-Efficient Supermarket Display Cases. December, 2004. Prepared by: Foster Miller, Inc. David H. Walker Principal Investigator Southern California Edison RTTC. Ramin T. Faramarzi Principal Investigator Oak Ridge National Lab Van D. Baxter

Technologies / controls	Potential saving (refrigeration) energy [46]	Application	Benefits / Key Features for Efficiency[47]
Tangential fan	2%	· All cabinets with fans	· Improve the coil airflow distribution. · For increased savings to be used ECM motor and VSD controller
Low-E / reflective glazing (K glass)	1 - 2%	· Glazed and delicatessen cabinets	· Reduction on radiant heat

The way the occupants / building manager use the appliances also influences energy performance. It is important to provide users with guidelines outlining the benefits of these appliances, and the best way to achieve maximum efficiency.

Relationship to Other Measures

Claiming this measure reduces energy use for refrigeration only.

Assumptions

The base case assumes standard refrigerated cases. The improved case is 10% more efficient. The reduction varies depending on the type of building.

Compliance Guidance

Design Stage	Post-Construction Stage
At the design stage one of the following must be used to demonstrate compliance: · Summary list of the refrigerated cases to be installed in the building, including quantity, energy use, and proof of certification by *Energy Star*, *EU Energy Efficiency Labeling Scheme, Energy Technology Product List (ETL),* or equivalent; and · Specifications from the manufactured detailing energy use.	At the post-construction stage one of the following must be used to demonstrate compliance: · Updated summary list of the refrigerated cases installed in the building, including quantity, manufacturer, and model; and · Proof of certification by *Energy Star*, *EU Energy Efficiency Labeling Scheme, Energy Technology Product List (ETL),* or equivalent; and · Specifications from the manufactured detailing energy use.

E38 – SMART METERS

Corresponds to HME21

Requirement Summary

This measure can be claimed when smart metering is provided in each unit of the building. The owners may subscribe to an online monitoring system or install a Home Electricity Management System (HEMS), which requires little additional equipment installation. Note that this measure cannot be claimed when 'prepaid meters' are installed as they are not considered smart meters under EDGE.

The smart meter must be able to show readings of the last hour, last day, last 7 days and last 12 months of usage data, and the devices should be accessible within the home. Other objectives of the smart meters and / or HEMS are:

- Measure home electricity use and real power;
- Analyze measurements;
- Relatively low price per home;
- The smart meters solution must be workable in offline households with no web dependency.

Intention

The intent is to reduce energy demand through increased awareness of energy consumption. With smart meters, end-users can appreciate, understand, and contribute to responsible use of energy in the building. Smart meters can display measurements and recommendations.

Approach/Methodologies

When smart meters are installed in each unit of the building, end-users receive immediate feedback that can result in 10 to 20% energy savings, as they are able to identify consumption in more detail than with conventional meters.

Potential Technologies/Strategies

Smart metering is designed to provide occupants with information on a real-time basis about their domestic energy consumption. This may include data on how much gas and electricity they are consuming, the costs, and the impact of their consumption on greenhouse gas emissions.

A detection unit (the transmitter) is affixed to an existing utility meter and tracks energy use. The display unit receives a wireless signal from the transmitter and displays the consumption information in real time and cost for the end user. Many companies also offer online monitoring systems[48] which require little to no additional equipment installation.

The benefits of smart metering include controlling demand; improving equipment performance by signaling the need for preventive maintenance or repairs; optimizing operational efficiency with controlled costs; and maximizing property values.

For best results it is recommended that separate smart meters be used for different uses, i.e. lighting, cooling, heating, hot water, and plug loads. This will offer better visibility of energy usage and therefore better management. Some design considerations for an optimal HEMS are as follows:

- Include a utility-grade power meter, with network interface to home broadband router, or access to cloud based data analysis, as an option;
- Consider an inductive power meter (clamp-on sensor) with wireless Home Area Network (HAN) connection to in-home display (IHD) or web browser; and
- Use an interface to utility electricity meter for data acquisition, data storage in logger device, HAN connection to IHD or web browser.

Figure 20. Home screen to of smart meter with display options to inform home users

48 For example, http://www.theenergydetective.com/ or http://efergy.com/media/download/datasheets/ecotouch_uk_datasheet_web2011.pdf

Relationship to Other Measures

The contribution made by the measure is reflected in the common amenities portion of the energy chart. Although EDGE does not show savings in other areas of energy consumption, this measure increases end user awareness, which in the long term can help to significantly reduce energy consumption from appliances, heating, cooling, and hot water.

Assumptions

The base case assumes conventional meters, while the improved case assumes smart meters to be installed in each unit.

Compliance Guidance

Design Stage	Post-Construction Stage
At the design stage, the following must be used to demonstrate compliance: · Electric drawings/specifications including make and model of smart meters and the connection with the electric system or equivalent system online; and / or · Manufacturer's specification of the smart meters.	At the post-construction stage, the following must be used to demonstrate compliance: · Photographs of the installed smart meters; and/or · Purchase receipt for the smart meters or subscription to the equivalent online system.

E39 – SOLAR HOT WATER COLLECTORS

Corresponds to HME19, HTE30, RTE28, HSE35, EDE29

Requirement Summary

This measure can be claimed if solar water heating is specified.

Intention

The installation of solar water heating will reduce the grid electricity (fossil fuels) used by the building for water heating.

Approach/Methodologies

To recognize energy reductions from installing solar collectors, a user must enter the proportion of hot water demand in the improved case that the solar collectors will deliver. EDGE uses this percentage to offset the amount of energy needed, displaying an approximate minimum area of collectors required to deliver the proportion of hot water demand. This will help auditors to check the size of the solar system against the EDGE estimate.

The amount of hot water delivered by the solar collectors is dependent on the amount of solar energy available, the roof pitch and profile, space available, shading factors, the orientation and angle of the solar collectors, and the type of solar collectors. The size of the storage tank also impacts the amount of hot water delivered, as a tank that is too small will reduce the quantity that can be stored. These factors should be considered by the design team.

Solar collector sizing calculators are available from manufacturers of solar collectors. Alternatively, online calculators or software can be used.

In some cases, solar collectors are centralized for a combination of buildings within the building project. In these cases, the central solar plant should be located within the site boundary of the project, or managed by a company within the control of the site owner. This is to ensure continued and sustainable management and access to the plant for future maintenance.

When solar hot water collectors are located off-site, then a contract with the management company in charge of the PV system must be provided as part of the documentation at post-construction stage.

Potential Technologies/Strategies

The two types of solar thermal collectors are flat plate and evacuated tube. Both types of solar collectors should ideally be installed at a tilt angle that takes advantage of the most useful altitude angles of the sun to maximize the solar heat available. This angle is approximately equal to the building location's latitude. The collectors should be angled towards the equator (towards the south in the northern hemisphere, and towards the north in the southern hemisphere). If this is not possible then facing the panels towards the southeast, southwest or even west is also acceptable, but panels should not be installed to face north in the northern hemisphere, and towards the south or east in the southern hemisphere. Solar collectors can also be installed horizontal to the ground. This is optimal in locations where the sun's azimuth (angle of the sun from the horizon) is vertically overhead at the desired peak production times. Where the sun is at other angles, the efficiency is adversely affected.

Table 52: Types of solar water collectors

Type	Description
Flat Plate Collectors	As their name suggests, they are flat and typically black. They are the most commonly used collectors and are the cheapest option. Flat plate collectors consist of an absorber plate, which is usually black chrome; a transparent cover which protects the absorber plate and reduces heat loss; tubes containing a fluid to take heat from the absorber plate; and an insulated backing.
Evacuated Tube Collectors	Evacuated tubes consist of a row of glass tubes. These glass tubes each contain an absorber plate fused to a heat pipe containing heat transfer fluid.

Relationship to Other Measures

This measure is inextricably linked to hot water consumption, which EDGE estimates based on the number of occupants, the efficiency of the hot water boiler, and the flow rates of the kitchen, showers, laundry and hand basin faucets. The required area of solar thermal collectors can therefore be reduced significantly by specifying low-water-use showers and faucets, as well as any water heating recovery technology.

Assumptions

The base case assumes that no solar thermal collectors are installed. The default improved case assumes 50% of total hot water demand in the improved case being met by the solar thermal installation. The default value of 50% must be overwritten by the user with the actual percentage applicable to the project. The area of the collector required to deliver the stated proportion of hot water demand assumes that flat plate collectors are used, and assumes that the collectors are installed at an optimum angle.

Compliance Guidance

To demonstrate compliance, the design team must briefly describe the system including the type of solar collector; the capacity of the storage tank and its location; and the size, orientation and installed angle of the panels.

EDGE will display the approximate area of panels required to deliver the proportion of hot water claimed by the design team. The required area is calculated using local climate data and assumes an optimum angle for the solar panel installation. The calculations assume use of flat plate collectors, therefore if the design team is using evacuated tube collectors the area can be reduced.

Design Stage	Post-Construction Stage
At the design stage, the following must be used to demonstrate compliance: · Roof plan and drawings showing location, orientation, and angle of the panels, which must be at least as much as the area estimated by EDGE; and · Manufacturer’s data sheet for the panels specified; or · Building’s hot water system schematic including solar panels.	At the post-construction stage, the following must be used to demonstrate compliance: · As-built plumbing schematics; and · As-built roof plan showing the location, orientation and angle of the panels; and · Photographs of the installed panels; or · Purchase receipts and delivery notes for the solar panels.

E40 – SOLAR PHOTOVOLTAICS

Corresponds to HME20, HTE31, RTE29, OFE30, HSE36, EDE30

Requirement Summary

This measure can be claimed if solar photovoltaic (PV) panels are installed on the building or the site and if the energy generated from the PV panels is used for operation of the building. Since a specific proportion of electricity is replaced by renewable energy, the PV panels are considered an energy efficiency measure.

Intention

Installing solar photovoltaic panels reduces the amount of electricity required from the grid.

Approach/Methodologies

To claim this measure, the design team needs to indicate the proportion of electricity demand that they would like to offset with the PV installation. This is the percentage of the annual electricity use (expressed in kWh/year) of the improved case that is met by the PV system. This percentage can be calculated using the electricity consumption from the EDGE improved case for the project, and the projected annual production from the PV system. For example, if the projected energy use for the improved case is 100 kWh/m^2/year, and the PV system will generate 10 kWh/m^2/year, 10% must be input into the model. EDGE will also indicate the peak power output (kWp) required to deliver that percentage. The design team must be able to demonstrate that the installation can deliver that kWp. The expected output of the solar panels is measured in kilowatt peak (kWp) and is based on the theoretical peak output of the panels under test conditions. The kWp can be obtained directly from the manufacturer.

For any project being split into multiple EDGE models, a total value must be calculated for the entire project and this value must be input into every model.

In some cases, the PV panels are centralized for a combination of buildings within the building project. In these cases, the central PV location/plant must be located within the site boundary of the project, or managed by a company within the control of the site owner. This is to ensure continued and sustainable management and access to the plant for future maintenance.

When PV panels are located off-site, a contract with the management company in charge of the PV system must be provided as part of the documentation at the post-construction stage.

Potential Technologies/Strategies

Many types of solar photovoltaic systems are available and different technologies convert solar energy into electricity with varying levels of efficiency. Efficiency levels of up to 22.5% can be achieved by some commercially available systems, but others are only capable of delivering as little as 5% efficiency. The majority of panels range from 14% to 16% efficiency rating[49]. Design teams should therefore ensure that the specified system achieves the maximum efficiency possible for the available capital.

Relationship to Other Measures

To maximize the percentage contribution from the solar photovoltaic installation, the electricity demand must first be minimized by reducing energy consumption (e.g., by using natural instead of mechanical ventilation, or by using automatic lighting controls).

Assumptions

The base case assumes that photovoltaic panels are not specified. The improved case assumes 25% of total energy demand being met by the solar panels, but the percentage can be adjusted by the user.

Compliance Guidance

To demonstrate compliance, the design team must briefly describe the system, including information on the type of solar photovoltaic system and the location, size, orientation and installed angle of the panels. EDGE will display the approximate kWp that is required to deliver the proportion of electricity demand claimed by the design team.

Design Stage	Post-Construction Stage
At the design stage, the following must be used to demonstrate compliance: · Supporting calculation showing the proposed solar photovoltaics will deliver sufficient electricity to achieve the claimed proportion of total demand, and at least as much as the area estimated by EDGE. If not, clear justification should be provided; and · Manufacturer's data sheet for the panels specified with information on Wp per square meter; and · The roof plan and/or other drawings showing the location, orientation and angle of the panels.	At the post-construction stage, the following must be used to demonstrate compliance: · As-built roof plan showing the location, orientation and angle of the panels if changed from the design; and · Purchase receipts and delivery notes for the solar panels; or · Photographs of the installed panels; and/or · Contract with the energy management company if the PV system is centralized or off-site.

[49] Source: https://news.energysage.com/what-are-the-most-efficient-solar-panels-on-the-market/ accessed Nov. 30, 2017

E41 – OTHER RENEWABLE ENERGY FOR ELECTRICITY GENERATION

Corresponds to HME22, HTE32, RTE31, OFE31, HSE37, EDE31

Requirement Summary

This measure can be claimed if the project utilizes electricity generated from renewable resources other than solar photovoltaics, such as Biomass, Wind, Geothermal and Hydropower. The renewable energy source must be located on the project site to claim savings. Because the renewable source replaces a proportion of the electricity generated from fossil fuels, renewable sources of electricity are considered an energy efficiency measure.

Intention

The intent of this measure is to reduce the use of electricity generated from fossil fuels such as coal.

Approach/Methodologies

To claim this measure, the design team needs to indicate the proportion of electricity demand offset with renewable energy generated on-site. The total annual electricity consumption of the improved case is calculated by EDGE. The design team must be able to demonstrate that the renewable electricity source can deliver the percentage of electricity consumption claimed by the project.

The renewable electricity source may be centralized for a combination of buildings/dwellings within the development. In these cases, the total must be calculated for the master project and the same average percentage must be used uniformly in all the models for the project.

Potential Technologies/Strategies

Several systems for generating electricity from renewable sources are available at varying levels of efficiency. Efficiency levels of 20% or more can be achieved by some commercially available systems, but others are only capable of delivering as little as 5% efficiency. Design teams must therefore ensure that the specified system achieves the maximum efficiency possible for the available capital.

Relationship to Other Measures

To maximize the percentage contribution from the renewable source of electricity, the electricity demand must first be minimized by reducing energy consumption (such as by using natural instead of mechanical ventilation or by using automatic lighting controls).

Assumptions

The base case assumes that no renewable source of electricity generation is being utilized. When the measure is selected, the default percentage of electricity generated from these sources is zero (0). The improved case shows improvement only after the editable fields for the measure have been filled. A user must select the appropriate source of renewable energy and assign to it the percentage of annual electricity consumption met by the source.

Compliance Guidance

To demonstrate compliance, the design team must briefly describe the system. EDGE will display the annual electricity demand of the improved case in kWh. The percentage of this demand met by the renewable energy system can be claimed by the design team.

Design Stage	Post-Construction Stage
At the design stage, the following must be used to demonstrate compliance: · Supporting calculation showing the proposed system will deliver sufficient electricity to achieve the claimed proportion of total demand; and · Manufacturer's data sheets for the proposed system; or · Engineering drawings showing the system size and location	At the post-construction stage, the following must be used to demonstrate compliance: · As-built documentation showing the location and size of the system; and · Photographs of the system; and/or · Purchase receipts and delivery notes of the system

E42 – OFFSITE RENEWABLE ENERGY PROCUREMENT

Corresponds to HME23, HTE33, RTE32, OFE32, HSE38, EDE32

Requirement Summary

The measure can be claimed if a contract has been signed for the procurement of new off-site renewable energy that is specifically allocated to the building project. Renewable energy includes any carbon-free energy that is generated without the use of fossil fuels, such as that sourced from solar, wind, tidal, or biomass resources. This measure does not impact operational CO_2 savings, but it reduces the total carbon footprint of the project. This measure can be claimed for a Zero Net Carbon[50] certification only once the project has achieved 40% or greater savings in Energy.

Intention

Investment in off-site renewable energy supports the creation of new clean energy resources on the electrical grid. This allows projects to access renewable energy even if they are located in a dense urban environment and do not have sufficient open space or solar access to generate energy on site. Supporting off-site renewable energy can accelerate the reduction of greenhouse gas emissions associated with the energy sector. Additionally, by increasing renewable energy capacity on the grid, these resources may become more accessible or affordable for a greater number of electricity consumers.

Approach/Methodologies

In order to claim this measure, the design team must specify the quantity of off-site renewable energy that was contractually procured for the building project. If an entity associated with the project has already made general procurements of off-site renewable energy at an organization level, it must be demonstrated that a specific allocation was made for the exclusive use of the building. Off-site renewable energy procurements are typically transacted in blocks of energy units over the course of a year, such as kilowatt hours or equivalent BTU of electricity. When off-site renewable energy procurements are entered into the EDGE app, the quantity is compared to the annual electricity use to give a percentage offset.

Potential Technologies/Strategies

Off-site renewable energy may be procured from a variety of sources that are typically regionally dependent. In some countries, utility providers have established formal programs to support renewable energy development through a premium rate that is charged directly to the consumer's electricity bill, known as "green power" purchasing. Alternatively, third-party providers may have established individual projects or other community-based cooperatives to allow collective procurement of renewable energy at the local level. Where regional

[50] "A Zero Net Carbon building is a highly energy efficient building that produces on-site, or procures, enough carbon-free renewable energy to meet building operations energy consumption annually." Source: Architecture 2030.

renewable energy resources do not exist, projects may also consider procurement of renewable energy certificates (RECs) or other transferrable credits that can be sourced from a broader range of locations. These credits essentially transfer the value of renewable energy generated from the system owner to a consumer on the open market.

Project teams should refer to their local jurisdiction or regulatory authority for a definition of acceptable forms of renewable energy. In general, the EDGE tool will not accept forms of renewable energy that involve the combustion of fossil fuels or other non-renewable carbon-based resources.

Relationship to Other Measures

Off-site renewable energy procurements may be made in combination with other measures that reduce the use of fossil fuel or carbon-based energy resources for building construction and operations. These may include energy efficiency measures that improve the passive performance of a building, such as increased insulation or higher efficiency glass; the reduction of fossil fuel energy use in active systems, such as through high efficiency equipment; or the replacement of fossil-fuel based electricity from the grid with on-site generated renewable energy. The ultimate goal of combining these energy use reduction and replacement measures would be to utilize renewable energy for all energy demands on site.

Assumptions

The base case assumes that no off-site renewable energy procurements have been made for the project.

Compliance Guidance

The design team must be able to provide documentation of the origin and type of off-site renewable energy procurements, including the name of the provider. This documentation should include a copy of a signed contract or other formal agreement to confirm allocation of the of the off-site renewable energy. Note: off-site renewable energy procurements must be associated with new projects that are retired from the market after the energy is procured.

Design Stage	Post-Construction Stage
No documentation is required at the design stage.	At the post-construction stage, the following must be used to demonstrate compliance: · Copy of contract or other formal document stating the quantity and term of renewable energy provided to the project; and · Description of the form of renewable energy that is procured and its origin or project name; and · Documentation that it meets the definition of an applicable local authority

E43 – CARBON OFFSET

Corresponds to HME24, HTE34, RTE33, OFE33, HSE39, EDE33

Requirement Summary

The measure can be claimed if a contract has been signed for investment in a carbon offset project. Carbon offsets represent funding for third-party action to reduce or recapture carbon emissions that would otherwise be emitted to the atmosphere. This measure does not impact operational CO_2 savings, but it reduces the total carbon footprint of the project. This measure can be claimed for a Zero Net Carbon[51] certification only once the project has achieved 40% or greater savings in Energy.

Intention

Investing in carbon offsets reduces the net impact of building construction and operations to the atmosphere. By putting a value on carbon emissions reduction, the market is incentivized to implement additional measures to mitigate carbon emissions impact.

Approach/Methodologies

In order to claim this measure, the design team must specify the amount of carbon offsets that have been procured with a signed contract. Typically, each carbon offset unit represents the mitigation of one metric tonne of carbon dioxide or equivalent greenhouse gas. When carbon offsets are claimed in the EDGE app, the offset value is compared to the total estimated carbon emissions of the improved case in order to calculate the total offset percentage

Potential Technologies/Strategies

Many different carbon offset products are available from providers that represent projects across a range of sectors and regions. While the most common carbon offset projects are related to funding new renewable energy installations, such as solar or wind energy, a number of other projects are available related to energy efficiency upgrades, methane or carbon capture and sequestration and forestry restoration. The EDGE tool does not make restrictions on the type or origin of carbon offsets, though project teams may choose to procure specific offset products based on their desired impact (e.g. support clean energy development) or a preference for locally-based projects. While the EDGE tool recognizes carbon offsets equally based on the equivalent metric tonnes of CO_2, the cost of individual carbon offsets may vary depending on regional availability and project type.

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[51] "A Zero Net Carbon building is a highly energy efficient building that produces on-site, or procures, enough carbon-free renewable energy to meet building operations energy consumption annually." Source: Architecture 2030.

Relationship to Other Measures

Carbon offsets may be applied in combination with other measures that reduce the emissions associated with building construction and operations. These may include energy efficiency measures that improve the passive performance of a building, such as increased insulation or higher efficiency glass; the reduction of fossil fuel energy use in active systems, such as through high efficiency equipment; or the replacement of fossil-fuel based electricity from the grid with on-site generated or off-site procured renewable energy. Together, carbon reduction measures can be combined with carbon offsets to achieve a zero-net carbon balance for the building.

Assumptions

The base case assumes that no carbon offsets have been procured for the project.

Compliance Guidance

The design team must be able to provide documentation of the origin and type of carbon offset procured, the organization issuing the offset, and evidence of third-party verification by the appropriate regulatory authority. Finally, a copy of a signed contract must be provided in order to confirm execution of the carbon offsets. Note: carbon offsets must be new projects that are retired after the offset is issued. Also, EDGE does not recognize carbon offsets that are based on materials combustion.

Design Stage	Post-Construction Stage
No documentation is required at the design stage.	At the post-construction stage, the following must be used to demonstrate compliance: · Documentation of the carbon offset provider, stating formal certification or other third-party verification by an appropriate authority; and · Description of carbon offset project, including the methods by which carbon reductions are made; and · Copy of contract or other formal document stating the amount of offsets procured in equivalent metric tonnes of CO_2

WATER EFFICIENCY MEASURES

Water efficiency is one of the three main resource categories that comprise the EDGE standard. To comply for certification purposes, the design and construction team must review the requirements for selected measures as indicated and provide the information.

Required measures in EDGE do not mean that the improved case must meet or exceed the baseline case. Rather, it means that the actual performance of water fixtures is required to be entered in EDGE. If the final installed fixtures have variation in performance for any reason, a weighted average of the performance metric must be used.

Note: Flow rates used in this User Guide are global baseline assumptions and may differ from rates used in EDGE for countries in which it has been calibrated.

The following pages explain each water efficiency measure by relaying the intention, approach, assumptions and compliance guidance requirements.

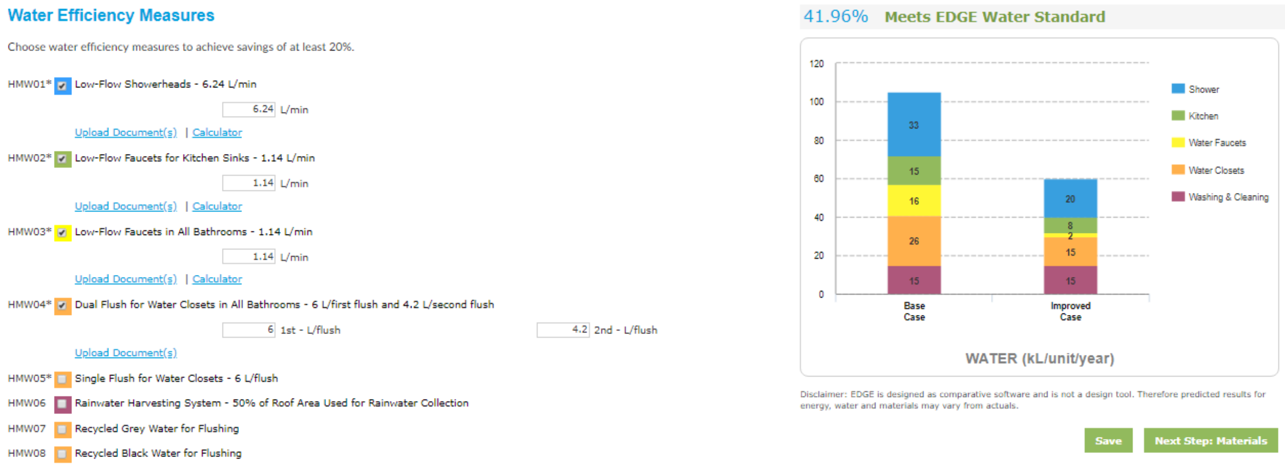

Figure 21. Screenshot of water saving measures in EDGE for Homes

W01* – LOW FLOW SHOWERHEADS

Corresponds to HMW01, HTW01, HSW01, EDW01

Requirement Summary

The actual flow rate of showerheads should be entered into the software in all cases, irrespective of the value. Savings can be achieved if the average flow rate of the showerheads is less than the base case flow rate.

Building Type	Spaces that must have low flow showerheads
Homes	All bathrooms
Hospitality	Guest rooms
Hospitals	All bathrooms
Education	All bathrooms

Intention

By specifying low-flow showerheads, water use is reduced without adversely affecting the functionality.

Approach/Methodologies

The flow rate of a shower can be as low as 6 liters per minute or greater than 20 liters per minute. As the flow rate of a showerhead is dependent on the water pressure, manufacturers often provide a chart which plots the flow rate at different pressures. For consistency, the flow rate used for the EDGE assessment must be that quoted for the operating pressure of 3 bar (43.5 psi). If the flow rates of the showerheads vary across a project, a weighted average must be used. Multiple measurements must be made across a variety of locations and floors to come up with a weighted average.

This measure can be claimed if the actual flow rate is entered and is lower than the Base Case. A flow rate that is lower than the default value for the design case contributes to even greater water savings.

Potential Technologies/Strategies

Many different showerheads are available that meet the flow rate required. In order to maintain user satisfaction at the lower flow rates, some manufacturers mix water with air to cause turbulence in the flow; this in turn gives an increased sense of pressure without increasing the flow rate.

Relationship to Other Measures

Higher flow rate showers use a significant quantity of hot water. Reducing the flow rate of the shower reduces the energy required to produce hot water. Therefore, both water consumption from showers, and energy consumption due to hot water, are reduced.

Assumptions

Assumptions for the base case and improved case vary by building type and location. The relevant improved case automatically gets displayed in the software. The base case flow rate can be deduced by changing the improved case values to get the same water consumption as the base case. Typically, it varies between 8 and 9 liters per minute at 3 bar (43.5 psi).

Compliance Guidance

Design Stage	Post-Construction Stage
At the design stage, the following must be used to demonstrate compliance: · Plumbing drawings/specifications including make, model, and flow rate of the showerhead(s); and · Manufacturer's data sheet for the showerhead(s) confirming the flow rate at 3 bar.	At the post-construction stage, the following must be used to demonstrate compliance: · On site test results by the auditor of the flow rate at the highest flow per minute, using a timer and a measurement container; and · Photographs of the installed showerhead(s); or, · Purchase receipts and delivery note for the showerhead(s).

W02* – LOW FLOW FAUCETS FOR WASHBASINS

Corresponds to HMW03, HTW02, HTW07, RTW03, OFW01, HSW02, EDW02

Requirement Summary

Savings can be achieved if the flow rate of the faucets specified for the washbasins in the building are less than the base case in liters per minute. This low flow rate must be obtained through the use of aerators and auto shut off controls.

Building Type	Spaces that must have low flow faucets
Homes	Bathrooms
Hospitality	Guest room bathrooms
	All other bathrooms
Retail	All bathrooms
Offices	All bathrooms
Hospitals	All bathrooms
Education	All bathrooms

Intention

By specifying aerators and auto shut-off faucets for washbasins and sinks, water use is reduced without adversely affecting functionality.

Approach/Methodologies

As the flow rate of a faucet is dependent on the water pressure, manufacturers often provide a chart that plots the flow rate at different pressures. To improve consistency, the flow rate used for the EDGE assessment must be that quoted for the operating pressure of 3 bar (43.5 psi). If this flow rate is not available, physical measurements can be made on site using a bucket of a known size and a timer to record the flow rate. Multiple measurements must be made across a variety of locations and floors to come up with a weighted average.

If the measure is claimed, then the assumed improved flow rate is 2 liters per minute. If the flow rate is greater than 2 liters per minute but lower than the baseline in liters per minute, the measure can still be claimed if the actual flow rate is entered. The lower the flow rate the greater the water savings.

Potential Technologies/Strategies

This measure includes two technologies fitted to the faucet – aerators and auto shut-off valves – which must be purchased as one product.

Aerators are small water-saving devices attached to the faucet that maintain user satisfaction at the lower flow rates. They mix water with air to cause turbulence in the flow; this in turn gives an increased sense of pressure without increasing the flow rate. They are also called flow regulators.

Auto shut-off faucets are activated by a push action or electronic sensors that allow the water flow to last for a programmed length of time, usually 15 seconds. After this period the faucet shuts off automatically, which is ideal for public and unsupervised washing areas.

Flow restrictors or aerators can be added on to the specified faucets to reduce the flow rate, which may be a cheaper alternative to purchasing a low-flow faucet.

Relationship to Other Measures

Reducing the flow rate of all the washbasin faucets in the building reduces the water demand and the energy required to produce hot water for the faucets.

Assumptions

The base case assumptions vary by location. Globally, the typical baseline flow rate is 6 liters per minute for all the faucets in all the washbasins; it is assumed that these faucets do not have auto shut-off technology. The improved case has aerated, auto shut-off faucets with a flow rate of 2 liters per minute in all the washbasins included in the measure.

Compliance Guidance

Design Stage	Post-Construction Stage
At the design stage, the following must be used to demonstrate compliance: • Plumbing drawings/specifications including make, model auto shut-off mechanism and flow rate of the washbasin faucet(s); or • Manufacturer's data sheet for faucet(s)/flow aerator(s) confirming the flow rate at 3 bar.	At the post-construction stage, the following must be used to demonstrate compliance: • On-site test results by the auditor of the flow rate at the highest flow per minute, using a timer and a measurement container; and • Photographs of the installed faucet(s); or • Purchase receipts and delivery note for faucet(s) which includes make, model and auto shut-off mechanism.

W03* – WATER-EFFICIENT WATER CLOSETS

Corresponds to HMW04, HMW05, HTW03, HTW06, RTW01, OFW02, HSW03, EDW03

Requirement Summary

This measure can be claimed when the water closets in all bathrooms of the building have a dual flush mechanism, or if they have an efficient single flush or flush valve. It is required that the actual flush rate of water closets be entered in EDGE in all cases, irrespective of the value.

Intention

Installing dual flush water closets helps to reduce the water used for flushing by providing a reduced flush option when a full flush is not required. Installing a more water efficient single flush water closet or flush valve similarly helps to reduce the water used to flush.

Approach/Methodologies

This measure will result in savings if the main flush is less than the base case in liters/flush and/or if the second flush is less than the base case in liters/flush. The default flush volumes for the improved case must be replaced with the actual values provided by the manufacturer.

In the case of a more efficient single flush system, select the Single flush/flush valve choice in EDGE. The actual flush value must be entered in the field for the volume of the flush. If the volumes of the flush vary across a project, a weighted average must be used. Multiple measurements must be made across a variety of locations and floors to come up with a weighted average.

Potential Technologies/Strategies

Dual-flush water closets have two flush levers where the smaller volume flush is recommended for liquid waste, and the higher volume flush for solid waste. The design team should be careful to select dual-flush water closets with clear intuitive controls, and a good flush performance rating. In some cases, dual-flush water closets can adversely increase the volume of water used if the method of use is not clear, or if they do not flush the waste adequately, requiring repeat flushes. The Environmental Protection Agency in the U.S. has a label, "WaterSense,"[52] with tests for water efficiency and performance, for high-performance water closets. The EPA website is a useful reference to identify dual flush water closets which have low water use but equivalent flushing performance to water closets with higher flush volumes.

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[52] Water Sense, US Environmental Protection Energy. 2014. http://www.epa.gov/WaterSense/index.html

Relationship to Other Measures

This measure is not affected by any other measure. However, this measure impacts building energy consumption due to a change in the energy use of water pumps as the total volume of water pumped changes (this portion of the energy consumption is included within the Energy Use category "Other").

Assumptions

The base case assumptions vary by location based on studies. Globally, the typical baseline is a flush volume of 8 liters. The improved case assumes a flush volume of 6 liters for the main flush and 3 liters for the reduced flush.

Compliance Guidance

Design Stage	Post-Construction Stage
At the design stage, the following must be used to demonstrate compliance: ▪ Plumbing drawings/specifications including make, model and flush volumes of water closet(s); and ▪ Manufacturer's data sheet for water closet(s) with information on the flush volume of the main and reduced flushes.	At the post-construction stage, the following must be used to demonstrate compliance: ▪ Photographs of installed water closet(s); or ▪ Purchase receipts and delivery note for water closet(s).

W04* – WATER-EFFICIENT URINALS

Corresponds to HTW05, RTW02, OFW03, HSW04, EDW04

Requirement Summary

This measure can be claimed when urinals in all bathrooms of the building have a flush volume which is lower than the base case. The actual flush rate of urinals must be entered in the software in all cases, irrespective of the value.

Intention

Fitting low-flush urinals reduces the water used for flushing, ensuring efficient water use and a high level of user satisfaction with flushing performance.

Approach/Methodologies

The flush volume is measured in liters/flush. The default flush volumes for the improved case must be replaced with the actual values provided by the manufacturer. The maximum flush volume of the urinal fixture as per the manufacturer must be specified.

If the flow rates of the urinals vary across a project, a weighted average must be used. Multiple measurements must be made across a variety of locations and floors to come up with a weighted average.

There are urinals available that do not use any water, referred to as waterless urinals. For waterless urinals, a value of 0.001 Lt/flush must be entered in the field provided.

Potential Technologies/Strategies

Urinals are only provided in bathrooms for males and only accept liquid waste. Their water saving potential depends on the number of male users in the building.

Urinals that are designed to be non-adjustable above their flush volume and that are provided with drain trap functionality tend to save more water. Pressurized flushing devices and a valve provide controls and therefore water savings.

In some cases, water efficient urinals can result in an increased risk of blockages caused by the reduced volume of water. The Environmental Protection Agency in the U.S. has a label, "WaterSense," with tests for water efficiency and performance[53]. The WaterSense label helps purchasers easily identify high–performing, water–efficient urinals, which can be found on the EPA website.

[53] Water Sense, US Environmental Protection Energy. 2014. http://www.epa.gov/WaterSense/index.html or http://www.epa.gov/WaterSense/products/urinals.html

Type of Urinal	Description
High efficiency	Urinals that flush 2 liters or less, which are currently available from several manufacturers.
Waterless or non-water	These urinals eliminate flush valves and water use. They need special maintenance to control odors and blockages with "urine stone" deposits in the drains. This adds operation costs as well as reduced life expectancy, which should be taken into account.
Wall-mounted urinals with flush valves	These urinals are flushed after each use, either manually or automatically. The automatic controls can be a timer or a valve, which are useful in bathrooms of high use, such as conference areas.

Relationship to Other Measures

This measure is not affected by any other measure. However, this measure impacts building energy consumption due to a change in the energy use of water pumps as the total volume of water pumped changes (this portion of the energy consumption is included within the Energy Use category "Other").

Assumptions

The base case assumptions vary by location. Globally, the typical baseline is a flush volume of 4 liters; the improved case assumes a flush volume of 2 liters. EDGE assumes on average that urinals are used two out of three instances of bathroom use in the male restrooms.

Compliance Guidance

Design Stage	Post-Construction Stage
At the design stage, the following must be used to demonstrate compliance: · Plumbing drawings/specifications including make, model and flush volume of the urinal(s); or · Manufacturer's data sheet for urinal(s) with information on the flush volume.	At the post-construction stage, the following must be used to demonstrate compliance: · Photographs of installed urinal(s); or · Purchase receipts and delivery note for urinal(s).

W05* – WATER-EFFICIENT KITCHEN FAUCETS

Corresponds to HMW02, HTW10, RTW04, OFW04, HSW07, EDW05

Requirement Summary

The actual flow rate of kitchen sink faucets must be entered in the software in all cases, irrespective of the value. Savings can be achieved if the flow rate of the faucets specified for the kitchen sinks is less than the base case specified in liters per minute.

In some cases, these savings are not applicable. For instance, in a building without a kitchen, there will be no kitchen water faucets and therefore no savings from this measure.

Intention

By specifying low-flow faucets for kitchen sinks, water use is reduced without adversely affecting the functionality. Hot water use is also reduced, reducing energy consumption for heating the water.

Approach/Methodologies

As the flow rate of a faucet is dependent on the water pressure, manufacturers often provide a chart that plots the flow rate at different pressures. To improve consistency, the flow rate used for the EDGE assessment must be that quoted for the operating pressure of 3 bar (43.5 psi). If this flow rate is not available, physical measurements can be made on site using a bucket of a known size and a timer to record the flow rate. If the flow rates of the faucets vary across a project, a weighted average must be used. Multiple measurements must be made across a variety of locations and floors to come up with a weighted average.

If the measure is claimed, the assumed improved flow rate defaults to 4 liters per minute. As long as the actual flow rate is lower than the base case in liters per minute, the measure can be claimed by specifying the actual flow rate. A lower flow rate contributes to greater water savings.

Potential Technologies/Strategies

Many different faucets are available that meet the flow rate required. To maintain user satisfaction at the lower flow rates, some manufacturers mix water with air to cause turbulence in the flow; this in turn gives an increased sense of pressure without increasing the flow rate.

Flow restrictors or aerators can be added on to the specified faucets to reduce the flow rate, which may be a cheaper alternative to purchasing a low-flow faucet.

Relationship to Other Measures

Higher flow rate kitchen faucets use a significant quantity of hot water. Reducing the flow rate of the kitchen faucets reduces the energy required to produce hot water.

Assumptions

The base case assumption varies by location. Globally, the typical baseline assumption is a flow rate of 8 liters per minute and the improved case is a flow rate of 4 liters per minute at 3 bar.

Compliance Guidance

Design Stage	Post-Construction Stage
At the design stage, the following must be used to demonstrate compliance: · Plumbing drawings/specifications including make, model and flow rate of kitchen faucet(s) or flow restrictor(s); or · Manufacturer's data sheet for faucet(s)/flow restrictor(s) confirming the flow rate at 3 bar.	At the post-construction stage, the following must be used to demonstrate compliance: · On site test results by the auditor of the flow rate at the highest flow per minute, using a timer and a measurement container; and · Photographs of the installed faucet(s) or flow restrictor(s); or · Purchase receipts and delivery note for faucet(s) or flow restrictor(s).

W06 – LOW FLOW PRE-RINSE SPRAY VALVES FOR DISHWASHING

Corresponds to HTW09, RTW06, HSW06

Requirement Summary

This measure can be claimed if the kitchens are fitted with low flow pre-rinse spray valves for rinsing the dishes prior to be placed in the washing machine. The pre-rinse valve specified should be 6 liters per minute or less.

Intention

By specifying low-flow pre-rinse valve, water use is reduced compared to a manual rinse of the dishes.

Approach/Methodologies

As the flow rate of the pre-rinse valve is dependent on the water pressure, manufacturers often provide a chart that plots the flow rate at different pressures. In order to improve consistency, the flow rate used for the EDGE assessment must be that quoted for the operating pressure of 3 bar (43.5 psi). If the flow rates of the spray valves vary across a project, a weighted average must be used.

If the measure is claimed, then the assumed flow rate is 6 liters per minute or less.

Some of the benefits of having an efficient pre-rinse valve in the kitchen of the hospital include having an efficient cleaning but using less water and energy, which then reduce the operational costs.

Potential Technologies/Strategies

Many different pre-rinse valves are available in the market; however as the flow rate required is low, efficient spray valves need to meet 6 liters per minute flow rate. In order to maintain user satisfaction at the lower flow rates, manufacturers mix water with air to cause turbulence in the flow; this in turn gives an increased sense of pressure without increasing the flow rate. Pre-rinse spray valves require a lot of pressure, which is given by the air within the valve, to remove the food waste prior to dishwashing. The savings are even more noticeable because pre-rinse valves use hot water, so when water is reduced the use of energy is also dropped.

Relationship to Other Measures

Water reduction in the 'Kitchen' section of the water chart is expected by low flow pre-rinse valves. Moreover, it shows reductions in energy due to 'water heating' and water pumps which is part of 'Others'.

Assumptions

The base case assumption is a flow rate of 19 liters per minute and the improved case is a flow rate of 6 liters per minute.

Compliance Guidance

Design Stage	Post-Construction Stage
At the design stage, the following must be used to demonstrate compliance: · Plumbing drawings/specifications including make, model, and flow rate of the pre-rinse valve(s); or · Manufacturer's data sheet for pre-rinse valve(s) confirming the flow rate at 3 bar.	At the post-construction stage, the following must be used to demonstrate compliance: · On site test results by the auditor of the flow rate at the highest flow per minute, using a timer and a measurement container; and · Photographs of the installed pre-rinse valve(s); or · Purchase receipts and delivery note for pre-rinse valve(s).

W07 – WATER-EFFICIENT DISHWASHERS

Corresponds to HTW08, RTW05, HSW05

Requirement Summary

This measure can be claimed if all the dishwashers installed in the building are water efficient (low consumption). This can be demonstrated when the purchased dishwasher(s) use less water than the base case. The base case dishwasher uses 5 liters per rack.

Intention

Minimize the water consumed by the dishwashers installed in the building.

Approach/Methodologies

The dishwasher consumption can be as low as 4 liters per load or greater than 21 liters per load. In a load two racks can be filled up. EDGE measures the water consumption per rack, which is calculated with the maximum total water consumption in liters divided by the number of racks in the dishwasher. The maximum total water consumption is taken from the manufactures datasheet on the cycle of the dishwasher that uses the most water. This measure can be claimed as long as the dishwasher uses 2 liters per rack or less.

Potential Technologies/Strategies

Dish washers overview	Key features for Efficiency
About 60% of the energy used by a dishwasher goes towards water heating; therefore, models that use less water also use less energy.	An efficient dishwasher should: · Be the right size for the building · Have several wash cycles · Enable pre-rinse to be skipped · Have soil sensors, which test how dirty dishes are and adjust the cycle to reduce water and energy use · Have more efficient jets, which use less energy to spray detergent and water · Have ‘no-heat’ drying feature, which circulates room air through the dishwasher by fans, rather than using electric heating · Have improved water filtration

In terms of dishwashers, the way that occupant use them also influence the water performance. It is important to provide users with guidelines outlining the benefits of these appliances, and the best way to achieve maximum efficiency.

Relationship to Other Measures

Water reduction in the 'Kitchen' section of the water chart is expected by water efficient dishwashers. Moreover, it shows reductions in energy due to equipment and pumps which is part of 'Others.'

Assumptions

The base case assumes standard dishwashers with a water consumption of 5 liters per rack, while the improved case assumes 2 liters per rack, which is 60% more efficient.

Compliance Guidance

Design Stage	Post-Construction Stage
At the design stage, the one of the following must be used to demonstrate compliance: · Summary of the dishwasher(s) to be installed in the building, including quantity and proof of maximum water use; or · Specifications from manufacture detailing water use.	At the post-construction stage, one of the following must be used to demonstrate compliance: · Updated summary of dishwasher(s) installed in the building including quantity, manufacturer and model; or · Proof of maximum water consumption from manufacture; or · Purchase receipts and delivery note for dishwashers

W08 – WATER-EFFICIENT FRONT-LOADING WASHING MACHINES

Corresponds to HTW04

Requirement Summary

This measure can be claimed when all the washing machines used in the laundry of a hotel or serviced apartment are front loading washing machines with high water efficiency.

Intention

Using high efficient front-loading washing machines reduces the water used for laundry. Other benefits, of high efficient washing machines, include energy saving due to the reduction of hot water use, better performance in cleaning the clothes, reduce fabric wear, and usually less detergent use.

Approach/Methodologies

The measure can be claimed if all the washing machines in the laundry use 6 liters of water per kilogram of clothes washed or less.

Potential Technologies/Strategies

There are two types of washing machines available in the market, top loading and front loading. While top loading need more water in order to cover the clothes inside, the front loading require about a third. The high efficiency washers are high-tech machines that use less water (both hot and cold water) and energy, while are more effective in cleaning the clothes compared to the standard ones. This is because in the front loading the washer moves the clothes through the water using gravity to create more agitation.

Relationship to Other Measures

Using a water-efficient washing machine not only reduces cold water demand but also hot water demand. Therefore, when this measure is selected the energy consumption is decreased due to water heating, as well as miscellaneous equipment, which is included within "Others".

Assumptions

The base case assumption is a standard washing machine that uses 10 liters per kilogram of clothes per cycle, while the improved case assumes a water usage of 6 liters per kilogram of clothes per cycle. This is equivalent to Water Consumption Factor (WCF)* of 5.94l/kg/cycle or 4.5gal/cu.ft/cycle.

Compliance Guidance

Design Stage	Post-Construction Stage
At the design stage, the following must be used to demonstrate compliance: ▪ Manufacturer's data sheet for washing machine(s) selected with information on the water consumption and maximum load capacity in kilograms.	At the post-construction stage, the following must be used to demonstrate compliance: ▪ Photographs of installed front loading washing machine(s); or ▪ Purchase receipts and delivery note for washing machine(s).

W09 – LAUNDRY RINSE WATER RECLAMATION SYSTEM

Corresponds to HSW08

Requirement Summary

This measure can be claimed if water recovery device with capacity to collect all water from rinse cycles of the washing machine(s) is installed and the collected rinse water being used in the washing cycles of the laundry facility.

Intention

By recovering the water from the rinse cycles of laundry the use of fresh water from the municipal supply can be reduced.

Approach/Methodologies

Hospitals can benefit of the rinse water recovery, as big portion of their water use is for the laundry facility. The water collected from the rinse cycle requires a simple filtration treatment, which removes soil, soap and other contaminants to make the water clean enough to be used again in another cycle.

In order to qualify the design team must demonstrate that the laundry facility has a water recovery device for the rinse water. The collected rinse water must have a recirculation and filtration system; and the recovery water must be used in the washing cycles of the laundry facility.

Potential Technologies/Strategies

Rinse water recovery is a system that collects the water from rinse cycles of the washing machines into a water tank, that then is pumped into a sequence of filters to ensure water is still effective at cleaning. Typically, this process starts in the holding tank, where ozone is injected to the water to remove odors and bacteria. Then, the water is pumped to a vibrating tank to remove lint. Then, another filter, which includes layers of sand and gravel traps the solids remaining in the water. The last filter in the sequence, removes soap and organic compounds. Finally, the water is send back to the washers to be used in the washing cycles. The system requires space for holding, filtration and storage tanks[54], which vary upon the capacity and size of the laundry facility.

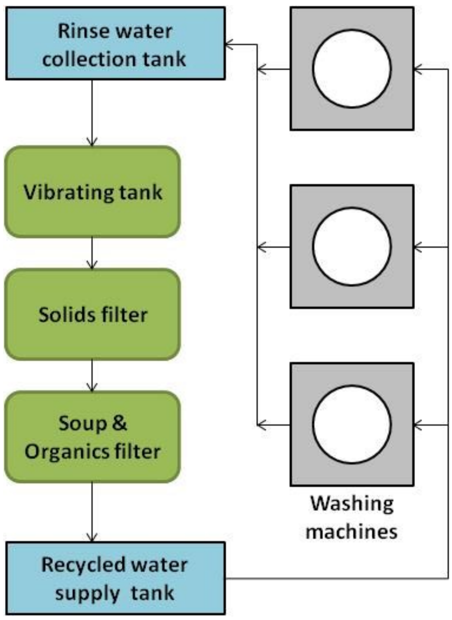

Figure 22. Schematic of the system to recover rinse water in laundry facilities

[54] Riesenberger, James and Koeller, J (2005). Commercial Laundry Facilities. http://www.allianceforwaterefficiency.org/commercial_laundry.aspx

Relationship to Other Measures

Claiming this measure only reduces the water demand for laundry. The contribution that the measure makes to the overall performance is not affected by any other measure.

Assumptions

The base case assumes no rinse water recovery from laundry, while the improved case assumes that all the water generated from the rinse cycles is recovered for the washing cycles within the laundry facility.

Compliance Guidance

In order to demonstrate compliance, the design team must provide documentation to support the claims.

Design Stage	Post-Construction Stage
At the design stage, the following must be used to demonstrate compliance: ▪ Hydraulic layout drawings of the laundry facility showing the location of the rinse water collection, filtration and reuse tanks.	At the post-construction stage, the following must be used to demonstrate compliance: ▪ As-built hydraulic drawings of the laundry facility showing the location of the rinse water collection, filtration and reuse tanks; and ▪ Photographs of installed equipment related to the system.

W10 – CONDENSATE WATER RECOVERY SYSTEM

Corresponds to HTW13, RTW08, OFW05, HSW10, EDW06

Requirement Summary

This measure can be claimed if a condensate water recovery device with the capacity to collect all condensate water from the cooling system is installed and the condensate water is used in landscaping, toilet flushing or for outdoor uses.

Intention

By recovering the condensate water from HVAC equipment, the use of fresh water from the municipal supply can be reduced.

Approach/Methodologies

Buildings benefit from condensate water recovery, which does not require much treatment and saves water for other purposes within the building and landscaping.

To qualify, the design team must demonstrate that the HVAC system has a collection device for the condensate water recovered. The collected condensate must have a piping system and collection tank or can be directed to the rain water collection tank if present. The collected water must be used in the building, such as for toilet flushing or on-site irrigation.

Potential Technologies/Strategies

In the context of buildings, condensate water recovery aims to re-use the water arising from the dehumidification of the air in HVAC or refrigeration systems. When the air passes through the cold coil of the system, the temperature of the air is decreased and the vapor (humidity) changes from gas to liquid, which can then be removed as condensate. It is essentially distilled water with low mineral content, but it can potentially contain harmful bacteria such as Legionella[55]. This water can potentially be used anywhere in the building except for drinking, if proper treatment to address biological contaminants is considered. Potential use of condensate water includes:

- Irrigation: generally safe to use without treatment, if used as surface irrigation;
- Cooling towers: treatment is needed;
- Water for decorative ponds or fountains: treatment is needed;
- Toilet and urinal flushing: treatment is needed;
- Rainwater recycle system: condensate can be a source to feed the system; and

[55] Boulware, B. Environmental leader magazine. *Air Conditioning Condensate Recovery,* January 15, 2013.

- Laundry and washing: biocide treatment required.

Condensate can be a constant source of water if the HVAC system is in use. It can generate between 11 to 40 liters/day per 100m² of conditioned space[56], depending on the HVAC system type and operation.

Collected water must be in accordance with local or international health and sanitary code requirements (whichever are more stringent).

Relationship to Other Measures

Claiming this measure reduces the water demand for the kitchen (dishwasher, rinse valve and faucets), bathroom faucets, the HVAC system and "Other" Water use, which is mainly cleaning.

Assumptions

The base case assumes there is no condensate water recovery from HVAC, while the improved case assumes that all condensate water generated from the HVAC system is recovered.

Compliance Guidance

To demonstrate compliance, the design team must provide documentation to support the claims.

Design Stage	Post-Construction Stage
At the design stage, the following must be used to demonstrate compliance: • Calculations for condensate water recovery specifying cooling load and water collected in liters per day; and • Hydraulic layout drawings showing the location of the recovery, collection and reuse technology.	At the post-construction stage, the following must be used to demonstrate compliance: • As-built hydraulic drawings with the location of the recovery, collection and reuse technology; and • Photographs of installed equipment related to the system.

[56] Alliance for Water Efficiency website. http://www.allianceforwaterefficiency.org/condensate_water_introduction.aspx

W11 – WATER-EFFICIENT LANDSCAPING

Corresponds to HTW11, RTW07, HSW09, EDW08

Requirement Summary

This measure can be claimed if water-efficient landscaping is incorporated within the building. The water-efficient landscaping measure can be claimed if less than 4 liters of water (excluding rainwater) will be used on average per square meter of landscaping per day.

Intention

Water-efficient outdoor landscaped areas can reduce the use of fresh water from the municipal supply, as well as fertilizers and maintenance cost, while preserving the habitat of plants and wildlife.

Approach/Methodologies

This measure can only be claimed if the outdoor landscaping areas, including lawns, gardens and ponds, will use less than 4 liters of water (excluding rainwater) per square meter a day throughout the year. This can be achieved by replacing the areas planted with water-intensive plants with native and adaptive plants. Detailed guidance for selecting water-efficient plants according to the local climate would normally be carried out by the landscape designer or the supplier of the plants. However, the following can be used as a rough guide:

Outdoor landscaping water consumption, including for lawns, gardens and ponds, is calculated as:

$$Landscape\ Water\ consumption = \frac{Landscape\ Water\ Requirements - Rainfall\ Volume}{Total\ Outdoor\ Landscaping\ Area}$$

Where:

Landscape Water Requirements = Average amount of water needed per day for all the plants within the outdoor landscaping area (in liters)

Rainfall Volume = Daily average annual rainfall (in liters)

Total Outdoor Landscaping Area = Area of outdoor lawns, gardens and ponds (m²)

Potential Technologies/Strategies

According to studies, "up to 50 percent of the water applied to lawns and gardens is not absorbed by the plants. It is lost through evaporation, runoff or being pushed beyond the root zone because it is applied too quickly or in excess of the plants' needs."[57] To offset this, following are the main considerations when designing a water-efficient landscaping area:

[57] US Environmental Protection Agency. http://www.epa.gov/WaterSense/docs/water-efficient_landscaping_508.pdf

- Use native and low water-using plants, as they require very little water beyond the local rainfall.
- Create zones of vegetation according to their water requirements. In this way, less water is wasted in irrigation as each zone is watered differently.
- Use an appropriate irrigation system. For example, a drip irrigation or under surface system can help reduce the water consumption compared to a sprinkler system.

Relationship to Other Measures

Claiming this measure reduces the water demand use for landscaping only.

Assumptions

The base case assumption is that 6 liters of fresh water per square meter a day is used on landscaping areas. The improved case assumes that 4 liters per square meter a day is used in the landscaping area.

Compliance Guidance

Design Stage	Post-Construction Stage
At the design stage, the following must be used to demonstrate compliance: · A landscape plan showing the zoning for plants and the type of plants used highlighting native species and the irrigation system selected; and · Description of the water requirements use in landscaped areas; or · Calculation of the landscape water consumption in liters/m²/day.	At the post-construction stage, the following must be used to demonstrate compliance: · Photographs of the planted species, landscaping area and irrigation system; or · Purchase receipt and delivery note for the plants and vegetation.

W12 – SWIMMING POOL COVER

Corresponds to HTW12, EDW09

Requirement Summary

This measure can be claimed if the building has pool(s) and these are fitted with a cover to prevent water and heat losses through evaporation.

Intention

Water and heat are lost through evaporation from the surface of the pool. The use of a cover for the entire pool(s) can reduce the use of fresh water from the municipal supply as well as energy for heating the pool.

A pool cover can also protect the pool from debris contamination, which reduces the use of chemicals and maintenance. A pool cover can provide shade in hot climates. For a heated pool in cold climates, a pool cover prevents heat loss during the night or when the pool is not in use; a transparent cover outdoors can also provide heat gain while reducing heat loss.

Approach/Methodologies

This measure can only be claimed if all the pools including outdoor and indoor pools have a suitable cover fitted to the entire pool surface. A suitable cover will include the following characteristics:

- Resistance to pool treatment chemicals and UV light;
- Thick and durable material;
- Insulation properties;
- Fully fitted to the pool;
- Easy to store and utilize; and
- Safe for both pool users and staff.

Potential Technologies/Strategies

Most pools lose water due to evaporation from the surface. Heat loss from pools occurs at the surface mostly due to evaporation, but also from radiation to the sky. These issues can easily be addressed with an affordable solution such as a pool cover. Pool covers have the following benefits:

Benefits	Description
Reduced water consumption	Surface water from a pool evaporates to the atmosphere. A pool cover for times when the pool is not in use can reduce the evaporation rate up to 98%, thus reducing the use of water to re-fill the pool.
Reduced energy consumption	In heated pools, a pool cover can be used both at daytime and nighttime to save energy, as it can gain heat as well as prevent heat losses. Standard pool temperature can rise by up to 4ºC (especially in dry and cold environments), if short-wave radiation from the sun passes through a transparent cover and heats the surface of the pool.

	Then at night, when there is no heat gain, the cover retains the heat by reducing long-wave radiant heat losses and the evaporation rate.
Reduced chemicals consumption	When the pool is covered, it is protected from debris (leaves, twigs and litter) contamination and therefore requires less chemical (chlorine) to clean up the pool. In addition, chemicals are not dispersed to the atmosphere due to the reduction of the evaporation rate.
Reduced need of mechanical ventilation (halls)	If evaporation is prevented when the pool cover is in place, then less mechanical ventilation is required in enclosed pool halls. In addition, dehumidifiers can be shut-off during off hours. These two factors reduce the energy consumption from the mechanical ventilation system.
Reduced maintenance	Both building and pool maintenance are reduced. This is because the reduction of humidity and condensation when the pool cover is in place lessens the maintenance to prevent mold on the building structure (especially in pool halls). In addition, pool maintenance is also lessened as chemicals are saved and debris contamination is avoided.

Relationship to Other Measures

This measure does not impact other measures.

Assumptions

The base case assumption is that the pool does not have a fitted cover. The improved case assumes that a pool cover is adequately fitted and that the cover reduces the evaporation rate, therefore 30% of water is saved each time that the pool is refilled.

Compliance Guidance

Design Stage	Post-Construction Stage
At the design stage, the following must be used to demonstrate compliance: • Sizing calculations and manufacturer's data sheet for a pool cover that fits the whole pool.	At the post-construction stage, the following must be used to demonstrate compliance: • Photographs of the installed pool cover; or • Purchase receipt and delivery note for the pool cover.

W13 – RAINWATER HARVESTING SYSTEM

Corresponds to HMW06, HTW14, RTW09, OFW06, HSW11, EDW07

Requirement Summary

This measure can be claimed if a rainwater collection system is installed to supply water for use within the project. This water must be re-used on the project site to replace water consumption from the municipal water supply. End uses may include flushing toilets, the HVAC system, cleaning the building, or irrigation of landscaping.

Intention

A rainwater harvesting system can reduce the use of fresh water from the municipal supply.

Approach/Methodologies

To qualify, the collected rainwater must be re-used on the project site, and demonstrate that it replaces municipal water supply. The project team must document both the need for municipal water supply for the end-use being served, and the fact that the collected rainwater is being directed to replace it. For example, the team could submit pictures that show the planned piping system connected to an irrigation system. This would ensure that the system is reducing municipal water use.

EDGE automatically calculates the approximate maximum quantity of water that can be collected by a rainwater harvesting system using rainfall data from the project location and the size of the roof area. Although the default assumption is that the roof will serve as the rainwater collection system, a rainwater collection system located on the grounds of the project is just as acceptable provided it is properly sized.

Detailed guidance for sizing a rainwater collection system is available on the worldwide web and would normally be carried out by the supplier of the system. However, the following can be used as a rough guide:

$$Rainwater\ Harvesting\ (m^3) = \ (Catchment\ Area * Rainfall\ Volume * Run\ off\ Coefficient/1000)$$

Where: *Catchment* Area = area of rooftop or hardscape (m^2).

Rainfall volume = average annual rainfall (mm), also called "amount potential"

Run-off coefficient = varies depending on the surface type. some examples are as follows:

Metal roof - 0.95, Concrete/asphalt roof - 0.90, Gravel roof - 0.80

If hardscape is included, it can also be expressed as a percentage of the roof area. For example, if a building has a 1000 m^2 roof and another 500 m^2 serving as rainwater catchment area, the EDGE input for % of Roof Area used can be 150%.

Potential Technologies/Strategies

The main consideration when designing a rainwater harvesting system is adequate sizing of the storage tank. The supplier/designer of the system must be able to advise on appropriate sizing, but the two key factors to consider when sizing the tank are the rate of supply (local rainfall data and collection area) and the demand (water use per day).

When harvesting the rain water, a dual piping system must be used to separate the rain water from the mains and to distribute the collected water for use at the project site (such as flushing toilets, the washing machine or showers).

Collected water must be in accordance with local or international health and sanitary code requirements (whichever are more stringent).

Relationship to Other Measures

Claiming this measure reduces the water demand for all uses considered by EDGE.

Assumptions

The base case assumption is that no rainwater is harvested. The improved case assumes that the rainwater harvesting system is adequately sized and that the rainwater collected is used internally for such purposes as flushing toilets and showers. When this measure is claimed, dual piping is required to avoid cross-contamination of water.

Compliance Guidance

Design Stage	Post-Construction Stage
At the design stage, the following must be used to demonstrate compliance: ▪ A system schematic showing the collection area, feed pipes and storage tank; and ▪ Sizing calculations for the rainwater harvesting system.	At the post-construction stage, the following must be used to demonstrate compliance: ▪ Photographs of the installed rainwater harvesting system and dual piping; or ▪ Purchase receipt and delivery note for the rainwater harvesting/storage system.

EDGE assumes that the rainwater is being used within the building. If the rainwater is being used only to irrigate the landscape, the project team must demonstrate that (1) there is need for irrigation with municipal water (in addition to just natural rainwater) and (2) that the recycled water will be directed to this use. This can be done with drawings of the plumbing layout at the design stage, and with pictures that show the planned piping system connected to the irrigation system at the post-construction stage.

W14 – GREY WATER TREATMENT AND RECYCLING SYSTEM

Corresponds to HMW07, HTW15, RTW10, OFW07, HSW12, EDW10

Requirement Summary

This measure can be claimed if there is a grey water recycling system that treats the waste water from the building, except the waste water from toilet flushing and kitchen sinks. This recycled water must be re-used on the project site to replace water consumption from the municipal water supply. End uses may include flushing toilets, the HVAC system, cleaning the building, or irrigation of landscaping.

Intention

By recycling the grey water, the use of fresh water from the municipal supply can be reduced. The load on the local water and sewage infrastructure is also reduced.

Approach/Methodologies

EDGE assumes that the recycled greywater will be used for flushing toilets. When this measure is claimed, EDGE automatically calculates the potential supply and reduces the municipal water demand for flushing toilets by that amount. EDGE assumes that wastewater from the building is collected and stored in sufficient quantities to meet the demand for flushing toilets. If the quantity of treated grey water is insufficient, then only a portion of the demand is shown to be met by the treated water.

A water balance model can be produced by the design team to demonstrate the potential for water recycling.

The recycled water must be reused for flushing toilets, with the remainder directed towards other uses. Where this water is not used for toilet flushing, the project must provide additional documentation that the system is indeed replacing municipal water supply. For example, if the recycled water is being used for irrigation only, then the project must demonstrate that (a) the landscaped area requires municipal water (in addition to just natural rainwater), and (b) the system is designed to serve the landscape, thus replacing water from the municipal supply. This can be done with drawings of the plumbing layout at the design stage, and with pictures that show the planned piping system connected to the irrigation system at the post-construction stage.

Potential Technologies/Strategies

When recycling the water, a dual piping system must be used to separate the recycled water from the mains.

Treated water must be in accordance with local or international health and sanitary code requirements (whichever is more stringent).

In some cases, the grey water treatment plant can be centralized for a combination of buildings within the development. In these cases, the central plant must fall within the site boundary of the project, or managed by a company within the control of the site owner. This is to ensure continuity of sustainable management and future access to the system for maintenance.

However, when the grey water treatment plant is located off-site, then a contract with the management company in charge of water treatment must be provided as part of the documentation at the post-construction stage.

Some jurisdictions may not permit the use of grey water in buildings for flushing; in such cases this measure cannot be claimed.

Relationship to Other Measures

The quantity of wastewater available depends on the efficiency of water fittings; more water-efficient buildings may have insufficient water available to completely offset the demand for flushing. This measure has an impact on "Other" Energy uses in the energy chart as water pumps required for operation of the system are included in in that category.

Assumptions

The base case assumes that there is no grey water recycling. The improved case assumes that grey water from the washbasins is reused in the building for flushing water closets.

Compliance Guidance

Design Stage	Post-Construction Stage
At the design stage, the following must be used to demonstrate compliance: ▪ A system schematic showing the plumbing layout including the dual plumbing lines; and ▪ Manufacturer's data sheet of the specified grey water treatment plant; and ▪ Calculations including the following: o Designed capacity of the grey water treatment system in m^3/day. o Quantity of grey water available daily to recycle in liters/day. o Efficiency of the grey water system to produce treated water in liters/day. o Water balance chart.	At the post-construction stage, the following must be used to demonstrate compliance: ▪ Date stamped photographs of the installed system; and ▪ Purchase receipt and delivery note for the water treatment and storage system; or ▪ Updated calculations or specifications if necessary; and/or ▪ Contract with the management company if the system is centralized or off-site.

W15 – BLACK WATER TREATMENT AND RECYCLING SYSTEM

Corresponds to HMW08, HTW16, RTW11, OFW08, HSW13, EDW11

Requirement Summary

This measure can be claimed if there is a black water recycling system that treats all the wastewater produced from all internal uses including from the toilets and kitchen. This recycled water must be reused on the project site. End uses may include flushing toilets, the HVAC system, cleaning the building, or irrigation of landscaping.

Intention

To reduce the use of water from the municipal supply and reduction of load on the local water and sewage infrastructure, a black water recycling system can be used.

Approach/Methodologies

When this measure is claimed, EDGE automatically calculates the potential supply of black water from the building and applies a reduction in municipal water demand across the end uses that can benefit from it. These include flushing toilets, cleaning of the building, the HVAC system, and irrigation of landscaping. The EDGE software assumes that most of the black wastewater from the building is collected, treated and stored properly to meet ongoing demand. If the quantity of treated black water is insufficient, then only a portion of the demand is shown to be met by the treated water.

A water balance model must be produced by the design team to demonstrate the potential for water recycling.

The recycled water must be reused for flushing toilets, with the remainder directed towards other uses. Where this water is not used for toilet flushing, the project must provide additional documentation that the system is indeed replacing municipal water supply. For example, if the recycled water is being used for irrigation only, then the project must demonstrate that (a) the landscaped area requires municipal water (in addition to just natural rainwater), and (b) the system is designed to serve the landscape, thus replacing water from the municipal supply. This can be done with drawings of the plumbing layout at the design stage, and with pictures that show the planned piping system connected to the irrigation system at the post-construction stage.

Grey water is included in black water, so there are no additional savings from a grey water system when a black water system is selected.

Potential Technologies/Strategies

Treated water must be in accordance with local or international health and sanitary code requirements (whichever is more stringent).

When recycling the water, a dual piping system must be used to separate the recycled water from the main.

In some cases, the black water treatment plant could be centralized for a combination of buildings within the development. In these cases, the central plant must fall within the site boundary of the project, or be managed by a company within the control of the site owner. This is to ensure continuity of sustainable management and future access to the system for maintenance.

If the black water treatment plant is located off-site, then a contract with the management company in charge of the water treatment must be provided as part of the documentation at the post-construction stage.

Some jurisdictions may not permit the use of recycled black water; in such cases this measure cannot be claimed.

Relationship to Other Measures

This measure affects the building energy use because the energy use of the water pumps required for the operation of the system is included in "Other" Energy use.

Assumptions

The base case assumes that there is no black water harvesting. The improved case assumes that all black water is re-used in the building for flushing water closets and urinals, landscaping, the HVAC system and cleaning ("Other").

Compliance Guidance

Design Stage	Post-Construction Stage

At the design stage, the following must be used to demonstrate compliance:
▪ A system schematic showing the plumbing layout including the dual plumbing lines; and
▪ Manufacturer's data sheet of the specified black water treatment plant; or
▪ Calculations including the following:
  o Designed capacity of the black water treatment system in m^3/day.
  o Quantity of black water available daily to recycle in liters/day.
  o Efficiency of the black water system to produce treated water in liters/day.
  o Water balance chart.
	At the post-construction stage, the following must be used to demonstrate compliance:
	▪ Photographs of the installed system; and
	▪ Updated calculations or specifications if necessary; or
	▪ Purchase receipt and delivery note for the water treatment and storage system; and/or
	▪ Contract with the management company if the system is centralized or off-site.

MATERIALS EFFICIENCY MEASURES

Materials efficiency is one of the three main resource categories that comprise the EDGE standard. To comply for certification purposes, the design and construction team must review the requirements for selected measures as indicated and provide the information.

The following pages explain each materials efficiency measure by relaying the intention, approach, assumptions and compliance guidance requirements. For a more detailed view of the embodied energy and images for the material options included in the Potential Technologies, see Appendix 2.

The Materials section includes Efficiency Measures for the following building elements: floor slabs, roof construction, external walls, internal walls, flooring, window frames, roof insulation and wall insulation. Structural elements are not included within this section because the structure should be designed as per safety and other engineering considerations and will not be altered. Structural engineers might consider lower embodied energy structures; however, EDGE excludes the structure from all embodied energy calculations. The main reason is to avoid any potential impact on the integrity of structural design considerations.

In addition to the selection of materials, the thickness can be specified for some elements in this section. However, changing these thickness values does not influence the building size or internal floor areas. For example, if the floor slab thickness is changed from 200mm to 500mm, the default volume and height of the room will be maintained in the calculations for other aspects, such as energy.

All materials measures marked with an asterisk (*) on the measure name such as HMM01* must be specified as per actual building conditions. For building elements where more than one material may be selected, a second predominant material that covers more than 25% of the area can optionally be indicated and marked with its percentage (%) area in the total project. Any additional materials beyond the first two must be represented by one of the two selected materials that is nearest to it in embodied energy. For projects being modeled with multiple EDGE models, the preferred method is to calculate the average distribution of materials over the entire project and use the same selections and percentage (%) figures across all models.

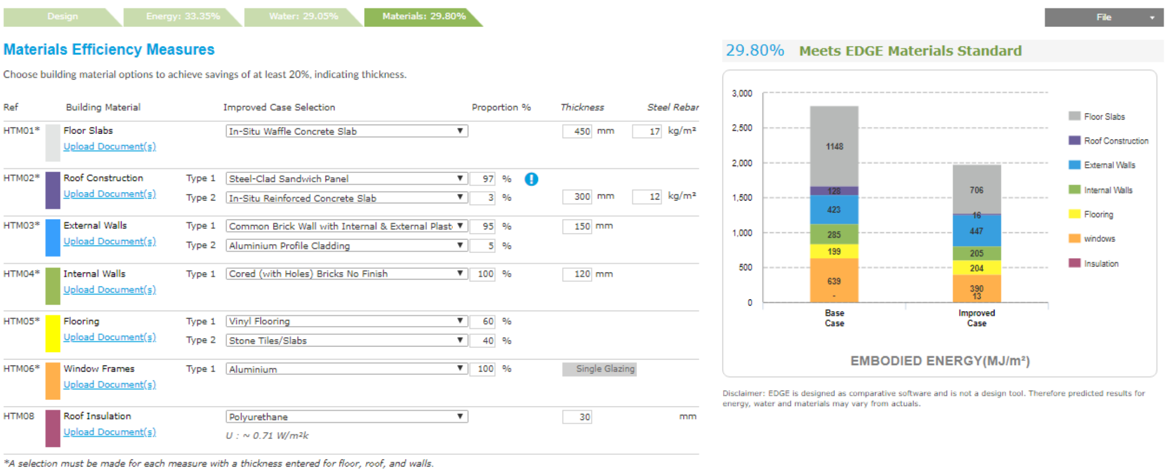

Figure 23. Screenshot of Materials saving measures in EDGE for Hospitality

MATERIALS EFFICIENCY MEASURES

EDGE provides default embodied energy values for the materials based on the EDGE Emerging Economies Construction Dataset (the EDGE Materials Embodied Energy methodology report is available on the EDGE website). Embodied energy values can vary widely based on the assumptions made; using a standardized dataset ensures that each material is evaluated following the same methodology for a fair comparison in EDGE. To ensure consistency, EDGE does not allow the addition of a custom material.

M01* – FLOOR SLABS

Corresponds to HMM01, HTM01, RTM01, OFM01, HSM01, EDM01

Intention

The intent is to reduce the embodied energy in the building by specifying a floor slab with lower embodied energy than a typical floor slab. The floor slab specification matching the actual building design must be entered in the software.

Approach/Methodologies

The design team must select the specification that most closely resembles the floor slab specified, and enter the thickness and steel rebar content, which are requirements of EDGE. Where there are multiple specifications, the predominant specification must be selected. A second predominant material that covers more than 25% of the area can optionally be indicated and marked with its percentage (%) area in the total project.

The specification for the floor slab must be that of the intermediary floor and not the ground floor, as the ground floor slab is often dictated by the ground conditions. The thickness must only include the structural slab. Do not include the thickness of the concrete used to level the floor slab for the finished flooring; this layer of screed is included in the embodied energy of the Flooring (EDM05).

Potential Technologies/Strategies

Following is a list of the floor slab options included in EDGE. The user must always try to select the specification that most closely resembles that of the building design.

In-Situ Reinforced Concrete Slab	One of the most popular and conventional floor slab construction types, this floor slab uses Portland cement, sand, aggregate, water and reinforcing steel.
In-Situ Concrete with >25% GGBS	Same as above, but with >25% Portland cement replaced on a one-to-one basis by weight with ground granulated blast furnace slag (GGBS), a by-product of iron and steel manufacturing processes. Replacement levels of GGBS vary from 30% to up to 85% as applicable. Typically, 40% to 50% of GGBS is used.
In-Situ Concrete with >30% PFA	Same as above, but with >30% Portland cement replaced by pulverized fuel ash (PFA), also known as fly ash, a waste product of coal fired at power stations. Using PFA as a cement replacement significantly reduces the overall carbon footprint of the concrete construction and helps to reduce risk of air and water pollution. In the promotion of environmental sustainability, PFA usage is one of the most highly recommended construction practices.

Concrete Filler Slab	Filler slab construction is technology based on the principal of using filler materials such as brick, clay tiles and cellular concrete blocks instead of concrete. The filler materials are used in the lower tensile region of the slab, which needs only enough concrete to hold the steel reinforcement together. Filler slab uses less concrete as well as steel due to the lightweight quality of the slab. It is also more cost-effective compared to conventional in-situ reinforced concrete slab.
Precast RC Planks and Joist System	This system uses precast concrete elements to construct intermediate floors and consists of (1) the plank, which represents smaller sections of the slab and is therefore of reduced thickness and reinforcement, and (2) the joist, which is a beam spanning across the room to provide a bearing for the planks. The planks are supported over partially precast RC joists which are set side by side and then joined together by pouring in-situ concrete over the entire roofing area. The monolithic action of the slab elements is enhanced by leaving reinforcement hooks projecting out of the joists and providing nominal reinforcement over the planks, before the in-situ concrete is poured. This method of construction saves time. Both elements of the floor – planks and joists – can also be manually produced at the site using wooden moulds.
Concrete Filler Slab with Polystyrene Blocks	This system is similar to concrete filler slab technology in that one of the aims is to reduce the volume of concrete required, which is more cost-effective compared to conventional in-situ reinforced concrete slab. It is comprised of precast concrete beams, a polystyrene form which then stays in place in the lower tensile region of the slab, and in-situ concrete. This system can be installed with or without insulation. Adding insulation to the floor slabs when they are exposed to outdoor or unconditioned area helps to improve thermal performance for heat gain and loss. If Concrete Beam Vault with Insulation is selected, then the embodied energy due to the insulation is added to the floor slab in the Materials chart and not to the chart's insulation section.
In-Situ Trough Concrete Slab	This system is similar to concrete filler slab technology in that one of the aims is to reduce the volume of concrete required, which makes it more cost-effective compared to conventional in-situ reinforced concrete slab. It is comprised of in-situ concrete troughs formed using removable void formers cast into the lower tensile region of the slab. The void formers are removed on completion.
In-situ Waffle Concrete Slab	Same as above, except it is comprised of in-situ concrete waffles, instead of troughs, formed using removable void formers.
Hollow Core Precast Slab	Hollow-core floor planks are precast concrete elements with continuous longitudinal voids providing an efficient lightweight section. When grouted, the effective shear key between adjacent hollow-core planks ensures that the system behaves similarly to a monolithic slab. Hollow-core planks may be used to produce a diaphragm to resist horizontal forces, either with or without a structural topping.

	Hollow-core planks, supported on masonry or steel can be used in domestic, commercial and industrial applications.
Composite Slim Floor Slabs with Steel I-beams	A slim floor is a system of precast, hollow core concrete units or deep composite steel decking supported on modified steel beams in the form of an asymmetric section with a wider bottom flange or a flat steel plate welded to the bottom flange of a standard UKC section. The beam becomes partially encased within the floor depth, resulting in a structural system with no down-stand beams, which leads to reduced floor-to-floor heights. The floor slab supports in-situ concrete that is placed level with (or above) the top flange of the beam.
Composite In-situ Concrete and Steel Deck (Permanent Shuttering)	Composite slabs comprised of reinforced concrete cast on top of profiled steel decking acts as formwork during construction and external reinforcement at the final stage. Additional reinforcing bars may be placed in the decking troughs, particularly for deep decking. They are sometimes required in shallow decking when heavy loads are combined with high periods of fire resistance.
Precast Concrete Double Tee Floor Units	Double tee units reduce the number of pieces to erect and minimize the number of connections between beams and columns. Double tees provide a safe, unobstructed work platform, immediately after erection, that is usable for light construction loads. Reinforced, cast-in-place concrete topping over the double tees provides a leveling course, proper drainage slopes and a structural floor diaphragm.
Thin Precast Concrete Deck and Composite In-situ Slab	The most common type of composite beam is one where a composite slab sits on top of a downstand beam, connected by a through deck welded shear studs. This form of construction offers advantages: the decking acts as external reinforcement at the composite stage, and during the construction stage as formwork and a working platform. It may also provide lateral restraint to the beams during construction. The decking is lifted into place in bundles, which are then distributed across the floor area by hand. This dramatically reduces the crane lifts when compared with a precast based alternative.
Timber Floor Construction	Timber floor construction is generally supported on timber joists. These joists are rectangular sections of solid timber spaced at regular intervals, built into the external wall. The covering to the floor is generally timber floorboards or sheet chipboard. The finish to the underside is generally sheet plasterboard. Joist hangers have become very common as the method of supporting the joist, avoiding building joists into walls. These are formed from galvanized steel and effectively form a shoe or seat for the joist to fit into, which is then built into the wall. They are also very useful for junctions between joists where previously a complicated carpentry joint would have been required.

Light Gauge Steel Floor Cassette	Pre-assembled sheet steel floor cassettes are manufactured off-site to stringent factory tolerances and can be bolted into the structure as a complete unit, providing a secure platform that can take a load straight away. This significantly speeds up the building process and ensures precise accuracy.
Re-use of Existing Floor Slab	Re-using an existing material avoids the use, and therefore embodied energy, of new materials. The re-use of the existing materials option in EDGE is highly desirable and is assigned an embodied energy value of zero. The material must be verifiably more than five years old to be classified as re-used. The material does not have to have been sourced from the project site.

Relationship to Other Measures

The contribution that the measure makes to the overall performance is not affected by any other measure.

Assumptions

The base case assumption is that the floor is constructed of a 200mm in-situ reinforced concrete slab.

Compliance Guidance

Design Stage	Post-Construction Stage
At the design stage, the following must be used to demonstrate compliance: · Floor sections showing build-up of the floor; or · Manufacturer's data sheet for specified building material if applicable; or · Bill of quantities with the floor slab specification clearly highlighted.	At the post-construction stage, the following must be used to demonstrate compliance: · Date stamped photographs of floor slabs taken during or after construction; and · Purchase receipt for the specified floor slab material; or · Delivery notes.

M02* – ROOF CONSTRUCTION

Corresponds to HMM02, HTM02, RTM02, OFM02, HSM02, EDM02

Intention

To select a roof specification with a lower embodied energy than the typical specification. The roof slab specification matching the actual building design must be entered in the software.

Approach/Methodologies

The design team must select the specification that most closely resembles the roof specified, and enter the thickness and steel rebar content, which are requirements of EDGE. Where there are multiple specifications the predominant specification must be selected.

In the Energy tab, a weighted average must be used for specifications such as solar reflectivity and U-value. This applies for green roofs as well. To specify a green roof, adjust these values in the Energy tab: (1) reflectivity of the roof (use the default of 70% if actual value is not available) and (2) insulation of the roof (U-value) to define the green roof condition. In the Materials tab, under roof insulation, select the insulation type used in the roof assembly.

Potential Technologies/Strategies

The following is a list of specifications included in EDGE. The user should always try to select the specification that most closely resembles that of the building design.

In-Situ Reinforced Concrete Slab	One of the most popular and conventional of all roof construction types, in-situ reinforced concrete slab uses Portland cement, sand, aggregate, water and reinforcing steel.
In-Situ Concrete with >25% GGBS	Ground granulated blast furnace slag (GGBS) is obtained by quenching molten iron slag (a by-product of iron and steel making) from the blast furnace in water or steam, producing a glassy, granular product which is then dried and ground into a fine powder. The roof construction technology for GGBS is the same as for the in-situ reinforced concrete slab but the Portland cement is directly replaced by industrial waste (GGBS) on a one-to-one basis by weight. Replacement levels of GGBS vary from 30% to up to 85% as applicable. In most instances, typically 40% to 50% of GGBS is used. Since the manufacture of Portland cement is energy intensive, replacing it with GGBS helps to reduce high-embodied energy content. Using GGBS also helps to reduce air and water pollution, leading to a more sustainable slab construction practice.
In-Situ Concrete with >30% PFA	Pulverized fuel ash (PFA), also known as fly ash, is a waste product of coal fired power stations. Using PFA as a cement replacement significantly reduces the overall carbon footprint of the concrete construction and helps to reduce risk of air

	and water pollution. In the promotion of environmental sustainability, PFA usage is one of the most highly recommended construction practices.
Concrete Filler Slab	Filler slab construction is technology based on the principal of using filler materials such as brick, clay tiles and cellular concrete blocks instead of concrete. The filler materials are used in the lower tensile region of the slab, which needs only enough concrete to hold the steel reinforcement together.
Precast RC Planks and Joist System	This system uses precast concrete elements to construct a roof and consists of two elements: The plank, which represents smaller sections of the slab and is therefore of reduced thickness and reinforcement, and The joist, which is a beam spanning across the room to provide a bearing for the planks. The joist is partially precast, with the remaining portion being cast in-situ after the planks are installed. The monolithic action of the slab elements is enhanced by leaving reinforcement hooks projecting out of the joists and providing nominal reinforcement over the planks, before the in-situ concrete is poured. The planks are supported over partially precast RC joists which are set side by side and then joined together by pouring in-situ concrete over the entire roofing area. Both elements of the roof – planks and joists – can be manually produced at the site using wooden moulds. This method of construction saves time.
Concrete Filler Slab with Polystyrene Blocks	This system is similar to concrete filler slab technology in that one of the aims is to reduce the volume of concrete required, which is more cost-effective compared to conventional in-situ reinforced concrete slab. It is comprised of precast concrete beams, a polystyrene form which then stays in place, in the lower tensile region of the slab and in-situ concrete. This system can be installed with or without insulation. Adding insulation to the roof slabs helps to improve thermal performance for heat gain and loss. If Concrete Beam Vault with Insulation is selected in the Materials section, the embodied energy due to the insulation is added to the roof slab and not to the insulation.
In-Situ Trough Concrete Slab	This system is similar to concrete filler slab technology in that one of the aims is to reduce the volume of concrete required, which is more cost-effective compared to conventional in-situ reinforced concrete slab. It is comprised of in-situ concrete troughs formed using removable void formers cast into the lower tensile region of the slab. The void formers are removed on completion.
In-Situ Waffle Concrete Slab	Same as above, except it is comprised of in-situ concrete waffles, instead of troughs, formed using removable void formers.
Hollow Core Precast Slab	Hollow core planks are precast concrete elements with continuous longitudinal voids providing an efficient lightweight section. When grouted, the effective shear key between adjacent hollow core planks ensures that the individual planks behave similarly to a monolithic slab. Hollow core planks may be used to produce

	a diaphragm to resist horizontal forces, either with or without a structural topping. Hollow core planks, supported on masonry or steel, can be used in domestic, commercial and industrial applications.
Composite Slim Slabs with Steel I-beams	A slim roof beam is a modified steel section in the form of a rolled asymmetric section (ASB beam) or a flat steel plate welded to the bottom flange of a standard UKC section. The bottom plate supports the slab so that the beam is partially encased within the slab depth, resulting in a structural system with no down-stand beams, which leads to reduced floor-to-floor heights. The slab may be in the form of precast, hollow core concrete units or deep composite steel decking, in both cases supporting in-situ concrete that is placed level with (or above) the top flange of the beam.
Composite In-situ Concrete and Steel Deck (Permanent Shuttering)	Composite slabs comprise reinforced concrete cast on top of profiled steel decking, which acts as formwork during construction and external reinforcement at the final stage. Additional reinforcing bars may be placed in the decking troughs, particularly for deep decking. They are sometimes required in shallow decking when heavy loads are combined with high periods of fire resistance.
Precast Concrete Double Tee Roof Units	Combined beam/column frame units reduce the number of pieces to erect and minimize the number of connections between beams and columns. Double tees provide a safe, unobstructed work platform, immediately after erection, that is usable for light construction loads. Reinforced, cast-in-place concrete topping over the double tees provides a leveling course, proper drainage slopes and a structural roof diaphragm.
Thin Precast Concrete Deck and Composite In-situ Slab	This construction technique utilizes a composite beam that is a structural beam composed of different materials that are interconnected so that the beam responds to loads as a unit. The most common type of composite beam is one where a steel-concrete composite slab sits on top of a downstand beam, connected by the use of through-deck welded shear studs. This form of construction offers a number of advantages: the decking acts as external reinforcement at the composite stage, and during the construction stage as formwork and a working platform. It may also provide lateral restraint to the beams during construction. The decking is lifted into place in bundles, which are then distributed across the roof area by hand. This dramatically reduces the crane lifts when compared with a precast alternative.
Brick Panel Roofing System	A brick roofing panel is made of first-class bricks reinforced with two mild steel bars of 6mm diameter. The joints between panels are filled with either 1:3 cement sand mortar or M15 concrete. The panels can be made in any size, but are typically 530mm x 900mm or 530mm x 1,200mm, depending on the requirements. The recommended maximum length is 1,200 mm.

Ferro Cement Roofing Channels	Ferro cement is a thin layer of reinforced cement, made of layers of continuous mesh covered on both sides with mortar. Ferro cement elements are durable, versatile, light and waterproof. They are not good thermal insulators. A ferro cement channel (FC) is a longitudinal element of a curved section (often semi-cylindrical). It is precast using moulds. It uses less cement and steel but has the same strength as RCC (reinforced cement concrete). This system is cheaper than RCC. Although it is easy to learn and to manufacture, constant quality control is needed during the manufacturing process.
Clay Roofing Tiles on Steel Rafters	With this type of roof construction, clay tiles are laid on steel rafters. Steel rafters ensure durability and strength but the embodied energy content of steel is higher than that of timber rafters, which need maintenance but have less embodied energy. EDGE estimates the embodied energy based on a thickness of 10mm for the clay roofing tiles and 8mm for the steel or timber rafters.
Clay Roofing Tiles on Timber Rafters	Same as above, except with timber rafters instead of steel rafters. Timber rafters need maintenance but have less embodied energy than steel. Timber sourced from a responsible forest management agency or from re-growth forests ensures the protection and conservation of natural forest communities.
Micro Concrete Tiles on Steel Rafters	Micro Concrete Roofing (MCR) Tiles are a cost-effective, aesthetic and durable alternative sloping roof technology. They have less embodied energy content than clay roof tiles and, as MCR tiles are lighter than other roofing tiles, they can be laid on a lighter weight structure.
Micro Concrete Tiles on Timber Rafters	Same as above, except on timber rafters.
Steel (Zinc or Galvanized Iron) Sheets on Steel Rafters	Zinc is a very dense and corrosion-resistant architectural material. It is non-ferrous, thus not subject to rusting. Its manufacturing includes crushing the zinc ore into particles, which are then concentrated by floatation. Then they are cast on a continuously rotating cylinder and rolled through pressure rolls to a specified thickness. They are often used as vertical cladding or on pitched roofs. Corrugated zinc sheets are widely used for roofs as they are easy to install due to being prefabricated; also, they are cheap and very light. The corrugations increase the bending strength of the sheet in the direction perpendicular to the corrugations, but not parallel to them.
Steel (Zinc or Galvanized iron) Sheets on Timber Rafters	Same as above, but on timber rafters.
Aluminium Sheets on Steel Rafters	Besides steel, aluminum is the most commonly used metal in construction. It is one of the lightest and easiest metals to manipulate, bend, shape, cast, fasten and weld, and is also very ductile, often extruded into shapes for architectural

	purposes. It can easily be drilled, tapped, sawed, planed and filed with hand tools, making it a yielding material for tradesmen to use. Aluminum has higher resistance to corrosion than steel. However, disadvantages include higher cost and embodied energy, greater thermal expansion, and lower fire resistance than steel.
Aluminium Sheets on Timber Rafters	Same as above, but on timber rafters.
Copper Sheets on Steel Rafters	When properly designed and installed, a copper roof provides an economical, long-term roofing solution. Its low life cycle costs are attributable to the low maintenance, long life and salvage value of copper. Unlike many other metal roofing materials, copper requires no painting or finishing.
Copper Sheets on Timber Rafters	Same as above, but on timber rafters.
Asphalt Shingles on Steel Rafters	Asphalt shingles are an effective roof covering material for sloped roofs. They can be successfully used on steeper pitches as well as moderately "low sloped" roofs (less than 1:3 i.e.100mm of vertical rise for every 300mm of horizontal run, or 18.5°), providing a few special application procedures are followed for low slopes. They should not be applied to roof slopes lower than 1:6.
Asphalt Shingles on Timber Rafters	Same as above, but on timber rafters.
Aluminum-clad Sandwich Panel	Sandwich panels provide a combination of high structural rigidity and low weight and are used in a variety of applications. An aluminum-clad sandwich panel is made of three layers: a low-density core with a thin skin-layer of aluminum bonded to each side. The core may be empty or honeycombed and may contain insulation.
Steel-clad Sandwich Panel	Sandwich panels provide a combination of high structural rigidity and low weight and are used in a variety of applications. A steel-clad sandwich panel is made of three layers: a low-density core with a thin skin-layer of steel bonded to each side. The core may be empty or honeycombed and may contain insulation. Steel is stronger than aluminum, so there is less likelihood of the core being honeycombed for strength.
Re-use of Existing Roof	Re-using an existing material avoids the use, and therefore embodied energy, of new materials. The re-use of existing materials option in EDGE is highly desirable and assigned an embodied energy value of zero. The material must be verifiably more than five years old to be classified as re-used. The material does not have to have been sourced from the project site.

Relationship to Other Measures

The selected roof specification will impact the thermal insulation of the roof surface, so the energy efficiency could be adversely affected or improved by selecting different roof specifications.

Assumptions

The base case assumption is that the roof is constructed of a 200mm in-situ reinforced concrete slab.

Compliance Guidance

Design Stage	Post-Construction Stage
At the design stage, the following must be used to demonstrate compliance: ▪ A section drawing of roof showing the materials and thicknesses; or ▪ Manufacturer's data sheet for specified building material; or ▪ Bill of quantities with the materials used for roof construction clearly highlighted.	At the post-construction stage, the following must be used to demonstrate compliance: ▪ Date stamped photograph of the roof taken during or after construction; and ▪ Purchase receipt for the building materials used for roof construction; or ▪ Delivery note for materials used for roof construction.

M03* – EXTERNAL WALLS

Corresponds to HMM03, HTM03, RTM03, OFM03, HSM03, EDM03

Intention

To select an external wall specification with a lower embodied energy than the typical specification. The external walls specification matching the actual building design must be entered in the software.

Approach/Methodologies

The design team must select the specification that most closely resembles the external walls specified, and enter the thickness, which is a requirement of EDGE. Where there are multiple specifications the predominant specification must be selected.

The external walls of the building are those directly exposed to the outdoor environment.

Potential Technologies/Strategies

The following is a list of the specifications included in EDGE. Only the broad wall types are described here; EDGE does not include options on plaster or finishing. The user should always try to select the specification that most resembles that of the building design.

Common Brick Wall with Internal & External Plaster	Common bricks, also known as fired clay bricks, are popular with builders as they are easily available and inexpensive. However, because common bricks are fired at high temperatures, normally achieved by the combustion of fossil fuels, they have high embodied energy.
Cored (with Holes) Bricks with Internal & External Plaster	Cored clay blocks are made of fired clay and have a holed cross-section. The holed structure means that there is less material per square meter of finished wall.
Honeycomb Clay Blocks with Internal & External Plaster	Honeycomb clay blocks are made of fired clay and have a honeycombed cross-section. The large size of the blocks enables rapid construction, and the honeycomb structure means that there is less material per square meter of finished wall. The honeycomb structure leads to improved thermal performance. Blocks can be customized. No mortar is needed in the vertical joints due to a tongue and grooved edge, reducing mortar use by up to 40%. The blocks are strong and have a high impact resistance. Honeycomb clay blocks have post-consumer value if dismantled carefully.
Medium Weight Hollow Concrete Blocks	Hollow concrete blocks are lightweight and easier to handle than solid concrete blocks. The lightness of the blocks helps in reducing the dead load of the masonry on the structure. The voids also marginally improve the thermal insulation and sound insulation of the block. The

	larger size of the blocks (compared to conventional burnt clay bricks) also reduces the number of mortar joints and the amount of cement mortar.
Solid Dense Concrete Blocks	Solid dense concrete blocks can be used in virtually any part of a building. They provide excellent sound insulation and their high strength makes them applicable for use in structural walls. However, the use of virgin aggregates and sand can lead to land or marine degradation and resource depletion, and the lack of supplementary materials in the cement results in increased embodied energy.
Autoclaved Aerated Concrete Blocks	Aerated concrete is a versatile, lightweight building material. Compared to solid dense concrete blocks, aerated concrete blocks have a lower density and excellent insulation properties. They are durable and have good resistance to sulfate attack and damage by fire and frost. Aerated concrete blocks are excellent thermal insulators. Based on volume, the manufacture of aerated blocks typically uses 25% less energy than other concrete blocks. They are lighter in weight which makes them easier to work with and saves energy in transportation.
Fly-Ash Stabilized Soil Blocks	Soil blocks have some inherent weaknesses that can be corrected using stabilization materials like fly ash or ground granulated blast furnace slag (GGBFS). Fly ash usually refers to industrial waste produced during coal combustion.
Compressed Stabilized Earth Blocks	Stabilized Compressed Earth Block (SCEB) technology offers a cost-effective and environmentally-friendly alternative to conventional building materials. The blocks are fire-resistant, provide better thermal insulation, and do not need to be fired, so they have a lower embodied energy.
Ground Granulated Blast (GGBS) Stabilized Soil Blocks	GGBFS is a by-product of the iron industry. The molten slag is cooled rapidly with water and is then ground into a fine cementations powder. GGBFS can then be used as a cement replacement in the blocks.
Rammed Earth Blocks/Walls	Rammed earth walls are more commonly used in arid areas. They are constructed by the compacting (ramming) of moistened subsoil into place between temporary formwork panels. When dried, the result is a dense, hard monolithic wall. As an alternative, rammed earth bricks are also available. The high moisture mass of rammed earth helps regulate humidity.
Precast Concrete Panels	Precast concrete is a construction product made by casting concrete in a reusable molding or "form" which is then cured in a controlled environment, transported to the construction site, and lifted into place. Precast cladding or curtain walls are the most common use of precast concrete for building envelopes. These types of precast concrete panels do not transfer vertical loads but simply enclose the space. They are only designed to resist wind, seismic forces generated by their own weight, and forces requiring transferring the weight of the panel to the support. Common cladding units include wall panels, window wall units, spandrels, mullions and column covers. These units can usually be removed individually if necessary.

	In some cases, precast panels are used as formwork for cast-in-place concrete. The precast panels act as a form, providing the visible aesthetics of the system, while the cast-in-place portion provides the structural component.
Straw Bale Blocks	Straw bale blocks are a rapidly renewable building material made from the dry stalk left in the earth after harvest, which is traditionally considered a waste product that is burned or baled and sold for animal use. It is a natural, non-toxic building material with low environmental impact and excellent insulation properties. Since it is very easy to work with it is a good choice for amateur or unskilled self-builders. Straw bale houses are finished and coated with cement stucco or earth-based plaster, sealing the straw from the elements and giving long-lasting protection with little maintenance. In contrast to the timber used for wood framing, straw can be grown in less than a year in a completely sustainable production system. The conversion of straw into a sustainable renewable resource to be used as a dominant building material could be especially beneficial in areas where the climate is severe and timber is scarce, but straw is plentiful.
Facing Brick and Timber Stud	Timber stud walls are a light weight construction technique which reduces the dead load of building and increases the pace of construction. Timber has relatively high embodied energy. Timber for stud walls should be made from local forest-department-certified wood or a forest-stewardship-council-certified wood, which helps to avoid the use of virgin wood for building construction activities.
Phosphogypsum Panel	Phosphogypsum is a waste product of the fertilizer industry. The use of phosphogypsum board in buildings is a substitute for natural gypsum.
Ferrocement Wall Panel	Ferrocement is a very simple construction of 2 to 5 layers of chicken wire over a frame made from reinforcing bar, with cement forced into the gaps and in a layer over the chicken wire reinforcing. The use of chicken wire makes ferrocement a very flexible building material that is strongest when curved.
In-Situ Reinforced Wall	More commonly used for floor slabs and roofs, in-situ reinforced concrete is also used to construct external walls. It has a high embodied energy due to the inclusion of Portland cement and uses sand, aggregate, water and reinforcing steel.
Cellular Light Weight Concrete Blocks	These blocks, which are environmentally friendly, are also called CLC blocks. The energy consumed in the production is only a fraction compared to the production of clay bricks. They are made from a slurry of cement, fly ash* and water, which is further mixed with the addition of pre-formed stable foam in an ordinary concrete mixer under ambient conditions. The addition of foam to the concrete mixture creates millions of tiny voids or cells in the material, hence the name Cellular Concrete. *Fly ash is a waste material from thermal power plants.

Stone Blocks	Limestone makes up about 10% of the total volume of all sedimentary rocks. Although limestone is found widely, developers and designers should opt for local extracted stone to reduce transport implications. Limestone is readily available and relatively easy to cut into blocks in a quarry. It is also long-lasting and stands up well to exposure, as it is hard, durable and commonly occurs in easily accessible surface exposures. Because of its mass, it has a high thermal inertia. However, limestone is a very heavy material, making it impractical for tall buildings, and relatively expensive as a building material.
Stone Blocks – Hand Cut	Same as above, except hand-cut and not polished. The embodied energy is in the extraction process and heavy transportation loads.
Stone Blocks – Machine Cut Unpolished	Quarried stone, machine-cut and not polished. The quarried stone is typically of medium hardness between limestone and granite. The embodied energy is in the extraction process and cutting with a mechanized saw.
FaLG Block	The Fly Ash-Lime-Gypsum blocks technology primarily uses industrial wastes such as fly ash (from thermal power plants), lime gypsum (from fertilizer industries), and sand (optional) to produce alternative walling materials. It reduces the environmental impacts associated with disposal of these industrial wastes, as well as avoids the environmental impacts associated with clay brick production, such as denudation of fertile topsoil. As the process for FAL-G blocks does not require sintering, the amount of energy (fossil fuels) for production is reduced. The manufacturing process consists of three main stages: - Mixing the materials: Fly ash is mixed with lime and gypsum. Chemical accelerator may or may not be added to it. - Pressing the mix in a machine: the mix is molded under pressure, also air/ sun drying may be undertaken; and - Curing the blocks for a stipulated period: the green block is water cured. In the presence of moisture, fly ash reacts with lime at ordinary temperature and forms a compound possessing cementations properties. After reactions between lime and fly ash, calcium silicate hydrates are produced which are responsible for the high strength of the compound. Generally, FAL-G blocks are grey in color, solid and have plain rectangular faces with parallel sides and sharp, straight and right-angled edges. They are used for the development of infrastructure, construction of pavements, dams, tanks and under water works.
Steel Profile Cladding	Steel, one of the strongest and most affordable materials, is a ferrous metal, meaning it contains iron. It has a favorable strength-to-weight ratio as well as provides elasticity. Other benefits include stiffness and fire and corrosion resistance. Steel wall cladding profiles create totally new economical solutions in both new building and renovation and in operating and maintenance. The profiles are versatile cladding that comes

	in a very broad range of shapes, finishing and colors that enable innovative designs. In addition, they can be installed with insulation for better thermal performance.
Aluminium Profile Cladding	Beside steel, aluminum is the most commonly used metal in construction. It is one of the lightest and easiest metals to manipulate, bend, shape, cast, fasten and weld, and is also very ductile, often extruded into shapes for architectural purposes. It can easily be drilled, tapped, sawed, planed and filed with hand tools, making it a yielding material for tradesmen to use. Aluminum is commonly used as wall cladding or curtain-walls, as its resistance to corrosion is higher than steel, and lighter than other metals. However, the disadvantages are the higher cost and embodied energy, greater thermal expansion, and lower fire resistance as compared to steel. Most exterior applications using aluminum alloys are anodized surfaces, which increases the metal durability, traps dyes and adheres to other finishes. Plastic coatings, which are applied electrostatically as a powder and then heat cured, are also used for cladding wall panels. This coating gives a durable protection layer, with a more uniform appearance. The finished appearance can range from clear to a wide variety of colors and textures, depending on the coating applied. In addition, the panels can be installed with insulation for better thermal performance.
Exposed Brick Wall with Internal Plaster	Same as brick wall, except with no external plaster. Common bricks are fired at high temperatures, normally achieved by the combustion of fossil fuels, and therefore have high embodied energy.
Exposed Cored (with Holes) Bricks with Internal Plaster	Same as cored brick wall, except with no external plaster.
Facing Brick and Hollow Concrete Blocks	Facing bricks are bricks made of fired clay and used as the exterior face of a wall. Hollow concrete blocks are used as the inner layer of the wall. They are lightweight and easier to handle than solid concrete blocks. The lightness of the blocks helps in reducing the dead load of the masonry on the structure. The voids also marginally improve the thermal insulation and sound insulation of the block. The larger size of the blocks (compared to conventional burnt clay bricks) also reduces the number of mortar joints and the amount of cement mortar.
Facing Brick and Solid Concrete Blocks	Same as above, except with solid concrete blocks instead of hollow concrete blocks. Their high strength makes them applicable for use in structural walls. However, the use of virgin aggregates and sand can lead to land or marine degradation and resource depletion, and the lack of supplementary materials in the cement results in increased embodied energy.
Polymeric Render on Concrete Block	The exterior layer is made of polymeric render. Polymer render is a dry premixed polymer and fiber-reinforced powder applied to precast concrete blocks. Requiring only a single coat, polymer render is weather tight when cured, but will freely allow transmission of water

	vapor. The render is both breathable and flexible. Life expectancy is often in excess of 30 years. The inside layer is made of concrete blocks.
Polymeric Render on Brick	Same as above, except the inner layer is brick. Because common bricks are fired at high temperatures, normally achieved by the combustion of fossil fuels, they have high embodied energy.
Precast Concrete Sandwich Panel	Precast concrete sandwich panels comprise an outer leaf of precast concrete, an insulating layer "sandwiched" in between, and an inner leaf of plain grey concrete with a power floated finish. The panels may be attached to a steel frame as a cladding panel, or they can form part of a precast structural frame where the inner leaf is load bearing and the external leaf is connected to and supported off the internal leaf using ties. The ties used in the precast structural frames are made of metal, plastic or epoxy and have low thermal conductivity to eliminate cold bridging. The thickness of the insulation depends on the required U-value. The shape, thickness and size of the concrete can be varied to meet the requirements of the project.
Brick Faced Precast Concrete Sandwich Panel	Same as above, except an exterior brick face is attached to the precast concrete sandwich panels.
Stone Faced Precast Concrete Sandwich Panel	Same as above, except an exterior stone face is attached to the precast concrete sandwich panels.
Glass Fiber Reinforced Concrete Cladding	Glass fiber reinforced concrete (GFRC) is an alternative to pre-cast concrete for building façades. Because of its strength, this type of cladding can be produced in thinner sections to meet complex architectural specifications, and is three to five times lighter than standard concrete. GFRC has excellent weather-proofing and fire-retardant qualities, and is more water and pollution-proof than standard concrete. Glass reinforced concrete offers greater versatility due to its superior compressive strength and flexibility. It is also easy to handle and fast to erect and mount on support systems due to its light weight.
Stone Profile Cladding	Stone profile cladding is a natural stone panel system consisting of Z-shaped interlocking panels, stone corner pieces (quoins) and integrated fixing clips. All edges on both straight and corner panels are made of hand-dressed stone. The stone cladding panel system uses large (approx.) 600 x 200 mm panels which allows the use of larger pieces of stone to build a panel, giving a natural appearance. It saves both time and money compared to traditional stone masonry.
Cement Fibre Boards on Metal Studs	Cement fibre board used to clad buildings may also be referred to as "siding" or "ship lap cladding." It has the advantage of being more stable than wood through an extreme range of weather conditions and it won't rot, twist or warp. It is used to replace timber cladding in new build and refurbishment projects. Boarding is often self-colored so it doesn't need painting. The board can be fixed to timber or steel studs, and is easily cut by scoring and snapping external corners and edges.

Cement Fibre Boards on Timber Studs	Same as above, except on timber studs instead of metal studs.
Timber Weatherboard on Timber Studs	Timber cladding can be used in many forms to achieve a wide variety of pattern, texture and colors ranging from the use of shingles or shakes through to prefinished panels. However, the most common form of timber cladding consists of boards laid vertically, diagonally or horizontally with either overlapping or flush faces. Timber for stud walls should be made from local forest-department-certified wood or a forest-stewardship-council-certified wood.
UPVC Weatherboard on Timber Studs	Same as above, except with UPVC weatherboard instead of timber weatherboard. UPVC (unplasticised polyvinyl chloride) is a tough, durable plastic. UPVC cladding looks similar to timber cladding but usually has a thinner section as UPVC can be easily moulded. It can be easier to work with UPVC than timber because it is manufactured with more accurate dimensions, does not twist, warp or split and there are no knots in it.
Clay Tiles Cladding (or "Terracotta Rainscreen Cladding") on Metal Studs	Terracotta rainscreen tiles are fixed onto a steel or aluminum substructure. The substructure is generally formed of vertical "T" support rails and adjustable brackets, or brackets fixed along the horizontal axis of the support wall. Terracotta tiles are then mounted on the substructure using self-tapping stainless steel screws or aluminum hollow rivets, and held in place at four points with proprietary clips. Terracotta tiles are made of clay fired at high temperatures, normally achieved by the combustion of fossil fuels, and therefore have high embodied energy.
Plasterboards on Timber Studs	Plasterboard is a form of wallboard manufactured using a core of gypsum plaster bonded to layers of paper or fiberboard. It can be mounted on timber studs.
Plasterboards on Metal Studs	Same as above, except mounted on metal studs instead of timber studs.
Curtain Walling (Opaque Element)	A curtain wall is a vertical building enclosure which supports no load other than its own weight and the environmental forces which act upon it. Curtain walls are not intended to assist in maintaining the structural integrity of a building. Dead loads and live loads are thus not intended to be transferred via the curtain wall to the foundations.
3-D Wire Panel with "Shot-crete" Both Sides	3D wire panel is a spatial structure consisting of the following elements: • Welded reinforcing mesh of high wire diameter 3mm and a mesh size 50 × 50mm • Diagonal wire (stainless or galvanized) wire of diameter 4mm • Core of expanded polystyrene of thickness 50 - 120mm • Concrete sprayed on the wire structure
Aluminum-clad Sandwich Panel	Sandwich panels provide a combination of high structural rigidity and low weight and are used in a variety of applications. An aluminum-clad sandwich panel is made of three layers:

	a low-density core with a thin skin-layer of aluminum bonded to each side. The core may be empty or honeycombed and may contain insulation.
Steel-clad Sandwich Panel	Sandwich panels provide a combination of high structural rigidity and low weight and are used in a variety of applications. A steel-clad sandwich panel is made of three layers: a low-density core with a thin skin-layer of steel bonded to each side. The core may be empty or honeycombed and may contain insulation. Steel is stronger than aluminum, so there is less likelihood of the core being honeycombed for strength.
Re-use of Existing Wall	Re-using an existing material avoids the use, and therefore embodied energy, of new materials. The re-use of existing materials option in EDGE is highly desirable and assigned an embodied energy value of zero. The material must be verifiably more than five years old to be classified as re-used. The material does not have to have been sourced from the project site.

Relationship to Other Measures

The selected external wall specification will impact the thermal insulation of the external wall element, so the energy efficiency could be adversely affected or improved by selecting different specifications.

Assumptions

The base case assumption is that the external wall is constructed of 200mm common bricks.

Compliance Guidance

Design Stage	Post-Construction Stage
At the design stage, the following must be used to demonstrate compliance: · Façade drawings clearly marking the external wall specification selected; and · Drawings of the external wall sections; or · Manufacturer's data sheet for specified building material; or · Bill of quantities with the materials used for the external wall clearly highlighted.	At the post-construction stage, the following must be used to demonstrate compliance: · Date stamped photograph of the wall taken during or after construction; and · Purchase receipt for the building materials used for wall construction; or · Delivery note for materials used for wall construction.

M04* – INTERNAL WALLS

Corresponds to HMM04, HTM04, RTM04, OFM04, HSM04, EDM04

Intention

To select an internal wall specification with a lower embodied energy than the typical specification. The internal wall specifications matching the actual building design must be entered in the software in all cases.

Approach/Methodologies

The design team must select the specification from the drop-down list that most closely resembles the internal walls specified, and enter the thickness, which is a requirement of EDGE. Where there are multiple specifications the predominant specification must be selected.

Potential Technologies/Strategies

The following is a list of the specifications included in EDGE. Only the broad wall types are described here; EDGE does not include options on plaster or finishing. The user must always try to select the specification that most closely resembles that of the building design.

Common Brick Wall with Plaster Both Sides	Common bricks, also known as fired clay bricks, are popular with builders as they are easily available and inexpensive. However, because common bricks are fired at high temperatures, normally achieved by the combustion of fossil fuels, they have high embodied energy.
Cored (with Holes) Bricks with Plaster Both Sides	Cored clay blocks are made of fired clay and have a holed cross-section. The holed structure means that there is less material per square meter of finished wall.
Honeycomb Clay Blocks with Plaster on Both Sides	Honeycomb clay blocks are made of fired clay and have a honeycombed cross-section. The large size of the blocks enables rapid construction, and the honeycomb structure means that there is less material per square meter of finished wall. The features listed below make honeycomb clay blocks an eco-friendlier building product: ◦ The honeycomb structure leads to improved thermal performance. ◦ Blocks can be customized. ◦ No mortar is needed in the vertical joints due to a tongue and grooved edge, reducing mortar use by up to 40%. ◦ The blocks are strong and have a high impact resistance. ◦ Honeycomb clay blocks have post-consumer value if dismantled carefully.

MATERIALS EFFICIENCY MEASURES

Medium Weight Hollow Concrete Blocks	Hollow concrete blocks are lightweight and easier to handle than solid concrete blocks. The lightness of the blocks helps in reducing the dead load of the masonry on the structure. The voids also marginally improve the thermal insulation and sound insulation of the block. The larger size of the blocks (compared to conventional burnt clay bricks) also reduces the number of mortar joints and hence the amount of cement mortar.
Solid Dense Concrete Blocks	Solid dense concrete blocks can be used in virtually any part of a building. They provide excellent sound insulation and their high strength makes them applicable for use in structural walls. However, the use of virgin aggregates and sand can lead to land or marine degradation and resource depletion, and the lack of supplementary materials in the cement results in increased embodied energy.
Autoclaved Aerated Concrete Blocks	Aerated concrete is a versatile, lightweight building material. Compared to solid dense concrete blocks, aerated concrete blocks have a lower density and excellent insulation properties. They are durable and have good resistance to sulphate attack and damage by fire and frost. Aerated concrete blocks are excellent thermal insulators. Based on volume, the manufacture of aerated blocks typically uses 25% less energy than other concrete blocks. They are lighter weight which makes them easier to work with and saves energy in transportation.
Fly-Ash Stabilized Soil Blocks	Soil blocks have some inherent weaknesses that can be corrected using stabilization materials like fly ash or ground granulated blast furnace slag (GGBFS). Fly ash usually refers to industrial waste produced during coal combustion.
Compressed Stabilized Earth Blocks	Stabilized Compressed Earth Block (SCEB) technology uses local soil mixed with sand if required and a small percentage (about 5-10%) of ordinary Portland cement (OPC) as the stabilizing agent. It offers a cost-effective and environmentally-friendly alternative to conventional building materials. The blocks are fire-resistant, provide better thermal insulation and do not need to be fired, so they have lower embodied energy.
Ground Granulated Blast Furnace Slag (GGBS) Stabilized Soil Blocks	GGBS is a by-product of the iron industry. The molten slag is cooled rapidly with water and is then ground into a fine cementations powder. GGBFS can then be used as a cement replacement in the blocks.
Rammed Earth Blocks/Walls	Rammed earth walls are more commonly used in arid areas. They are constructed by the compacting (ramming) of moistened subsoil into place between temporary formwork panels. When dried, the result is a dense, hard monolithic wall. As an alternative, rammed earth bricks are also available. The high moisture mass of rammed earth helps regulate humidity.

Precast Concrete Panels	Precast concrete is a construction product made by casting concrete in a reusable molding or "form" which is then cured in a controlled environment, transported to the construction site, and lifted into place. Precast cladding or curtain walls are the most common use of precast concrete for building envelopes. These types of precast concrete panels do not transfer vertical loads but simply enclose the space. They are only designed to resist wind, seismic forces generated by their own weight, and forces requiring transferring the weight of the panel to the support. Common cladding units include wall panels, window wall units, spandrels, mullions and column covers. These units can usually be removed individually if necessary. In some cases, precast panels are used as formwork for cast-in-place concrete. The precast panels act as a form, providing the visible aesthetics of the system, while the cast-in-place portion provides the structural component.
Straw Bale Blocks	Straw bale blocks are a rapidly renewable building material made from the dry stalk left in the earth after harvest, which is traditionally considered a waste product that is burned or baled and sold for animal use. It is a natural, non-toxic building material with low environmental impact and excellent insulation properties. Since it is very easy to work it is a good choice for amateur or unskilled self-builders. Straw bale houses are finished and coated with cement stucco or earth-based plaster, sealing the straw from the elements and giving long-lasting protection with little maintenance. In contrast to the timber used for wood framing, straw can be grown in less than a year in a completely sustainable production system. The conversion of straw into a sustainable renewable resource to be used as a dominant building material could be especially beneficial in areas where the climate is severe and timber is scarce, but straw is plentiful.
Ferrocement Wall Panels	Ferrocement is a very simple construction of 2 to 5 layers of chicken wire over a frame made from reinforcing bar, with cement forced into the gaps and in a layer over the chicken wire reinforcing. The use of chicken wire makes ferrocement a very flexible building material that is strongest when curved.
In-Situ Reinforced Wall	More commonly used for floor slabs and roofs, in-situ reinforced concrete is also used to construct walls. It has a high embodied energy due to the inclusion of Portland cement and uses sand, aggregate, water and reinforcing steel.

Cellular Light Weight Concrete Blocks	These blocks, which are environmentally friendly, are also called CLC blocks. The energy consumed in production is only a fraction compared to the production of clay bricks. They are made from slurry of cement, fly Ash*, and water, which is further mixed with the addition of pre-formed stable foam in an ordinary concrete mixer under ambient conditions. The addition of foam to the concrete mixture creates millions of tiny voids or cells in the material, hence the name Cellular Concrete. *Fly ash is a waste material from thermal power plants.
Stone Blocks	Limestone makes up about 10% of the total volume of all sedimentary rocks. Although limestone is found widely, developers and designers should opt for local extracted stone to reduce transport implications. Limestone is readily available and relatively easy to cut into blocks in a quarry. It is also long-lasting and stands up well to exposure, as it is hard, durable and commonly occurs in easily accessible surface exposures. Because of its mass, it has a high thermal inertia. However, limestone is a very heavy material, making it impractical for tall buildings, and relatively expensive as a building material.
Stone Blocks – Hand Cut	Same as above, except hand-cut and not polished. The embodied energy is in the extraction process and heavy transportation loads.
Stone Blocks – Machine Cut Unpolished	Quarried stone, machine-cut and not polished. The quarried stone is typically of medium hardness between limestone and granite. The embodied energy is in the extraction process and cutting with a mechanized saw.

FaLG Block	The Fly Ash-Lime-Gypsum blocks technology primarily uses industrial wastes such as fly ash (from thermal power plants), lime gypsum (from fertilizer industries) and sand (optional) to produce alternative walling materials. It reduces the environmental impacts associated with disposal of these industrial wastes, and avoids the environmental impacts associated with clay brick production, such as denudation of fertile topsoil. As the process for FAL-G blocks does not require sintering, the amount of energy (fossil fuels) for production is reduced. The manufacturing process consists of three main stages: - Mixing the materials: Fly ash is mixed with lime and gypsum. Chemical accelerator may or may not be added to it. - Pressing the mix in a machine: the mix is molded under pressure, also air/sun drying may be undertaken; and - Curing the blocks for a stipulated period: the green block is water cured. In the presence of moisture, fly ash reacts with lime at ordinary temperature and forms a compound possessing cementations properties. After reactions between lime and fly ash, calcium silicate hydrates are produced which are responsible for the high strength of the compound. Generally, FAL-G blocks are grey in color, solid and have plain rectangular faces with parallel sides and sharp, straight and right-angled edges. It is also used for development of infrastructure, construction of pavements, dams, tanks and under water works.
Common Brick Wall No Finish	Same as common brick wall, except without any plaster finish.
Cored (with Holes) Bricks No Finish	Same as cored brick wall, except without any plaster finish.
Precast Concrete Sandwich Panel	Precast concrete sandwich panels comprise an outer leaf of precast concrete, an insulating layer “sandwiched” in between, and an inner leaf of plain grey concrete with a power floated finish. The panels may be attached to a steel frame as a cladding panel, or they can form part of a precast structural frame where the inner leaf is load bearing and the external leaf is connected to and supported off the internal leaf using ties. The ties used in the precast structural frames are made of metal, plastic or epoxy and have low thermal conductivity to eliminate cold bridging. The thickness of the insulation depends on the required U-value. The shape, thickness and size of the concrete can also be varied to meet the requirements of the project.

Cement Fiber Boards on Metal Studs	Cement fiber board used to clad buildings may also be referred to as "siding" or "ship lap cladding." It has the advantage of being more stable than wood through an extreme range of weather conditions and it won't rot, twist or warp. It is used to replace timber cladding in new build and refurbishment projects. Boarding is often self-colored so it doesn't need painting. The board can be fixed to timber or steel studs, and is easily cut by scoring and snapping external corners and edges.
Cement Fiber Boards on Timber Studs	Same as above, except on timber studs instead of metal studs.
Plasterboards on Timber Studs	Plasterboard is a form of wallboard manufactured using a core of gypsum plaster bonded to layers of paper or fiberboard. It can be mounted on timber studs.
Plasterboards on Timber Studs with Insulation	Same as above, except with insulation between the timber studs.
Plasterboards on Metal Studs	Same as above, except mounted on metal studs instead of timber studs.
Plasterboards on Metal Studs with Insulation	Same as above, except with insulation between the metal studs.
3-D Wire panel with "Shot-crete" Both Sides	3D wire panel is a spatial structure consisting of the following elements: • Welded reinforcing mesh of high wire diameter 3mm and a mesh size 50 × 50mm • Diagonal wire (stainless or galvanized) wire of diameter 4mm • Core of expanded polystyrene of thickness 50 - 120mm (embodied energy of insulation is not included in this material) • Concrete sprayed on the wire structure
3-D Wire Panel with "Shot-crete" Both Sides with Insulation	Same as above, except that the embodied energy of insulation is included in this material.
Re-use of Existing Wall	Re-using an existing material avoids the use, and therefore embodied energy, of new materials. The re-use of the existing materials option in EDGE is highly desirable and assigned an embodied energy value of zero. The material must be verifiably more than five years old to be classified as re-used. The material does not have to have been sourced from the project site.

Relationship to Other Measures

The specification of internal walls does not affect other EDGE measures but can impact acoustic performance.

Assumptions

The base case assumption is that internal walls are constructed from 200mm common brick plastered on both sides.

Compliance Guidance

Design Stage	Post-Construction Stage
At the design stage, the following must be used to demonstrate compliance: · Drawings of the internal wall sections; or · Manufacturer's data sheet for building materials used for internal wall specifications if available; or · Bill of quantities with the materials used for the internal wall clearly highlighted.	At the post-construction stage, the following must be used to demonstrate compliance: · Date stamped photograph of the wall taken during or after construction; and · Purchase receipt for the building materials used for wall construction; or · Delivery note for materials used for wall construction.

M05* – FLOORING

Corresponds to HMM05, HTM05, RTM05, OFM05, HSM05, EDM05

Intention

To select a flooring specification with a lower embodied energy than the typical specification. The floor type specification matching the actual building design must be entered in the software.

Approach/Methodologies

The design team must select the specification that most closely resembles the floor finish specified. Where there are multiple specifications the predominant specification must be selected.

Potential Technologies/Strategies

The following is a list of the specifications included in EDGE. The user must always try to select the specification that most closely resembles that of the building design.

Ceramic Tile	The advantage of tiles is that they are hard wearing, which minimizes the maintenance required. However, tiles are not maintenance free, as the grout requires maintenance. The manufacture of tiles uses large amounts of energy due to the firing required and therefore tiles have a high embodied energy.
Vinyl Flooring	Vinyl flooring is water resistant, low maintenance and inexpensive. It is easy to install and is durable. However, vinyl flooring has a high embodied energy and can release harmful volatile organic compounds after installation. Although durable, vinyl flooring must be laid on a flat, smooth surface. An uneven surface might cause wearing and holes which are difficult to repair, as vinyl is usually laid in a single piece.
Stone Tiles/Slabs	While stone tiles can often be sourced locally and have a low embodied energy, they can be expensive.
Finished Concrete Floor	More commonly referred to as "screed," cement plaster is often used as a preparation layer for soft or flexible floor finishes or tiles. Cement plaster can be used as a finish layer, but it can be chipped more easily than other hard flooring options.
Linoleum Sheet	Linoleum, often referred to as lino, is a floor covering made from solidified linseed oil (linoxyn), pine rosin, ground cork dust, wood flour and mineral fillers such as calcium carbonate. These materials are added to a canvas backing; pigments are often added to the materials. Lino can be used as an alternative to vinyl and has a much lower embodied energy.

Terrazzo Tiles	Terrazzo tiles are a hard-wearing option for flooring which require very little maintenance. Terrazzo floors can be laid in situ by pouring concrete or resin with granite chips and then polishing the surface. Alternatively, terrazzo tiles are manufactured in a factory before being laid onsite.
Nylon Carpets	Most nylon carpets have a very high embodied energy because of the large amount of energy used in their manufacture but also because nylon is made from oil. Nylon carpets have good acoustic properties and help to reduce reverberation times as well as the transfer of impact sound.
Laminated Wooden Flooring	Laminated wooden flooring is more dimensionally stable than solid wood flooring so it can be used in rooms prone to changes in moisture levels or where underfloor heating is used. Due to the thickness of the finish layer the number of times that it can be refinished is reduced, but the initial capital cost is lower than for solid wood flooring.
Terracotta Tiles	Terracotta is fine-grained, orange or reddish-brown fired clay that is used for several construction and decorative purposes, primarily roof and floor tiles. The name comes from Italian, which means "baked earth," as it is cooked or fired earth or soil. The color varies slightly depending on the clay used. It is waterproof and a very sturdy material. Its durability and resistance to both fire and water make it an ideal building material. It is also lighter than stone, and it can be glazed for extra durability or to provide a wide variety of colors, including finishes that resemble stone or metal patina. Terracotta is a relatively inexpensive material.
Parquet/Wood Block Finishes	Parquet is wood block flooring in a geometric pattern. It is available in either solid or engineered construction, both of which can be manufactured to have an aged, rustic appearance. Solid parquet wood flooring is more traditional. Engineered wood flooring is composed of layers with a wood species forming the top flooring surface, and two or more under layers of wood running at 90° to each other. The crisscrossed layers increase stability which enables the product to be installed over all types of sub floors and to be used with underfloor heating.
Plant Fiber (Seagrass, Sisal, Coir or Jute) Carpet	Natural flooring has low embodied energy, but it has some disadvantages. It can be sensitive to changes in environment or atmosphere; the product may expand or shrink if fitted in an area such as a bathroom or kitchen where there is a constant change in temperature. Natural fiber flooring may also stain easily. Also, grass contains its own natural oils which makes it slippery on stairs. It's also not as hardwearing as other natural-fiber floorings such as sisal or coir.
Cork Tiles	Cork has low embodied energy and is environmentally friendly. It can be harvested from the same tree for about two hundred years. Harvesting is done with minimal impact on the environment and no trees are cut down to manufacture cork products. Advanced coating technology provides highly resistant and long-lasting protection even in high traffic environments.

Re-use of Existing Flooring	Re-using an existing material avoids the use, and therefore embodied energy, of new materials. The re-use of existing materials option in EDGE is highly desirable and assigned an embodied energy value of zero. The material must be verifiably more than five years old to be classified as re-used. The material does not have to have been sourced from the project site.

Relationship to Other Measures

Although flooring does not affect other measures in EDGE it can impact acoustic performance.

Assumptions

The base case assumption is that ceramic tile flooring is specified.

Compliance Guidance

Design Stage	Post-Construction Stage
At the design stage, the following must be used to demonstrate compliance: ▪ Drawings clearly marking the flooring specification selected; or ▪ Manufacturer’s data sheet for building materials used for floor specifications; or ▪ Bill of quantities with the materials used for the flooring clearly highlighted.	At the post-construction stage, the following must be used to demonstrate compliance: ▪ Date stamped photograph of the flooring once fitted; and ▪ Purchase receipt for the specified building materials used as a floor finish; or ▪ Delivery note for materials used for flooring.

M06* – WINDOW FRAMES

Corresponds to HMM06, HTM06, RTM06, OFM06, HSM06, EDM06

Intention

To select a window frame specification with a lower embodied energy than the typical specification. The window frame specification matching the actual building design must be entered in the software.

Approach/Methodologies

The design team must select the specification that most closely resembles the windows specified. Where there are multiple specifications the predominant specification must be selected.

Potential Technologies/Strategies

The following is a list of the specifications included in EDGE. The user must always try to select the specification that most closely resembles that of the building design.

Aluminium	The two metals typically used for window frames are aluminum or steel. Aluminum is lighter weight and does not rust like a ferrous metal such as steel, but the embodied energy is much higher. The advantage of using metal window frames is that they are strong, light and require less maintenance than other materials used for window frames. However as metal conducts heat very well, the thermal performance of metal windows is not as good as other materials. To reduce heat flow and U-Value, metal frames can include a thermal break between the inside and outside of the frame.
Steel	Similar to aluminum windows above, except steel windows are heavier than aluminum and require some maintenance to protect from rust (unless stainless steel is used). Steel has somewhat better thermal performance than aluminum.
Timber	Timber window frames insulate relatively well, but they also expand and contract in response to weather conditions. Timber frames can be made from either softwood or hardwood. Softwood frames are much cheaper, but are likely to require more regular maintenance. The maintenance required can be reduced by using aluminum or vinyl cladding.
UPVC	uPVC window frames are made of extruded polyvinyl chloride (PVC) with ultraviolet light (UV) stabilizers to keep sunlight from breaking down the material. uPVC window frames are low maintenance as they do not require painting. If the cavities of uPVC frames are filled with insulation, they have very good thermal performance.

Aluminium Clad Timber	Aluminum cladding is fixed to wooden framing members with a space for ventilation purposes. Timber and aluminum have high embodied energy. The extruded aluminum sections are designed for strength and rigidity, to prevent deformation at the fastening points. Often used in commercial applications, these windows are also suitable for residential applications where low maintenance is important, such as social housing and high-rise developments.
Re-use of Existing Window Frames	Re-using an existing material avoids the use, and therefore embodied energy, of new materials. The re-use of existing materials option in EDGE is highly desirable and assigned an embodied energy value of zero. The material must be verifiably more than five years old to be classified as re-used. The material does not have to have been sourced from the project site.

Relationship to Other Measures

The choice of window frame material will have an impact on thermal performance. EDGE does not directly take account of this as it is already reflected in the manufacturer's calculation of the window U-value.

Assumptions

The default assumption is that window frames are aluminum.

Compliance Guidance

Design Stage	Post-Construction Stage
At the design stage, the following must be used to demonstrate compliance: · Façade drawings marking the window frame(s) specification; or · Manufacturer's data sheet for glazing specified; or · Bill of quantities with the windows/window frames highlighted.	At the post-construction stage, the following must be used to demonstrate compliance: · Date stamped photograph of the installed windows; and · Purchase receipt for the specified windows; or · Delivery notes for windows.

M07 & M08 – INSULATION

Corresponds to HMM07, HMM08, HTM07, HTM08, RTM07, RTM08, OFM07, OFM08, HSM07, HSM08, EDM07, EDM08

Intention

To select insulation with a low embodied energy. If the building has insulation on the walls and the roof, then the insulation type matching the actual building specifications must be entered in the software.

Approach/Methodologies

The design team must select the specification that most closely resembles the insulation specified. Where there are multiple specifications the predominant specification must be selected.

As the base case assumes that no insulation is specified, the embodied energy calculation will not take account of the insulation selected unless the Insulation of Roof Surface and/or Insulation of External Walls measures are selected in the energy efficiencies section.

Potential Technologies/Strategies

The following is a list of the specifications included in EDGE. The user must always try to select the specification that most closely resembles that of the building design.

Polystyrene	Polystyrene has the highest embodied energy per square meter of any other insulation type. There are two types of polystyrene insulation: Expanded Polystyrene (EPS) insulation is made from small beads of polystyrene that when heated cause them to expand; they are then mixed with a blowing agent (pentane). Expanded polystyrene is available in board form or as beads. Boards are produced by placing the beads in moulds and heating them to fuse the beads together. Typical applications of EPS boards are for insulation of walls, roofs and floors. Polystyrene beads are frequently used as cavity fill in masonry walls. Extruded Polystyrene (XPS) is made by mixing polystyrene with a blowing agent under pressure and forcing it through a die. As it emerges from the die it expands into foam; it can then be shaped and trimmed. XPS is slightly stronger than EPS, and although it is used in many of the same applications as EPS, it is particularly suitable for use below ground or where extra loading and/or impacts might be anticipated.
Mineral Wool	Rock-based mineral wool is made by melting rock and recycled steel slag and spinning it into fibers. The insulation is available in different densities depending on the required functionality. Higher densities provide better sound insulation but poorer thermal insulation. Applications include masonry cavity walls, timber frame walls and insulation for roof rafters, lofts and suspended floors. Mineral wool has low resistance for moisture.
Glass Wool	Glass wool insulation is manufactured in a similar way to rock wool, though the raw materials are different as well as the melting process. Glass wool is made from silica sand, recycled glass, limestone and soda ash. Higher densities provide better sound insulation but poorer thermal insulation. Applications include masonry cavity walls, timber frame walls, and insulation for roof rafters, lofts and suspended floors.

Polyurethane	Polyurethane (PUR), a closed-cell plastic, is formed by reacting two monomers in the presence of a blowing agent catalyst (polymerization). Polyisocyanurate foam (PIR) is an improvement on polyurethane (there is a slight difference in the constituents and the reaction is conducted at higher temperatures). PIR is more fire-resistant and has a slightly higher R Value. Applications include wall, floor and roof insulation. Polyurethane is also popular in laminate form in SIPS and as an insulation backing to rigid boarding such as plasterboard.
Cellulose	Four major types of loose-fill cellulose products have been developed for differing uses in a building under a variety of brand names. These are characterized as: 1. Dry cellulose 2. Spray applied cellulose 3. Stabilized cellulose 4. Low dust cellulose.
Cork	Cork has low embodied energy and is environmentally friendly. It can be harvested from the same tree for about two hundred years. Harvesting is done with minimal impact on the environment and no trees are cut down to manufacture cork products.
Woodwool	Woodwool boards have been used in buildings for decades and are a popular substrate for lime plaster. Strands of wood, bound together with a small proportion of Portland cement, provide a good background for lime plasters, eliminate thermal bridges in pillars, beams, inter-story facings and radiator niches and provide insulation of flat and sloping roofs; provide acoustic insulation of walls and insulation from floor noise; as well as fire resistant coverings.
Air Gap <100mm Wide	In principle, the use of cavities is similar to the use of an insulating material. Air is a poor conductor of heat, therefore still air trapped in an air space between two layers of a wall or roof acts as a barrier to heat transfer.
Air Gap >100mm Wide	Gaps larger than 100mm encourage convection and are not effective insulators.
No Insulation	This option must be selected if no insulation is specified for the roof or walls.

Relationship to Other Measures

The base case assumes that no insulation is used. If the measures for roof surface and/or external walls insulation are selected, then the improved case will assume that polystyrene insulation is specified. If either mineral wool or glass wool is selected on the insulation dropdown, it will result in a small percentage improvement over the base case, due to the greater embodied energy in polystyrene insulation.

Assumptions

The base case assumption is that no insulation is specified. The improved case assumes that polystyrene insulation is specified.

Compliance Guidance

Design Stage	Post-Construction Stage
At the design stage, the following must be used to demonstrate compliance: · Drawings marking the insulation specification selected; or · Manufacturer's data sheet for insulation specified; or · Bill of quantities with the insulation materials highlighted.	At the post-construction stage, the following must be used to demonstrate compliance: · Date stamped photograph of the insulation installed during construction; and · An invoice for the specified insulation; or · Delivery note for materials used for insulation.

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APPENDIX 1. COUNTRY SPECIFIC CONSIDERATIONS

South Africa

SANS Building Regulations

SANS Building Regulations standards are referenced in the EDGE software to ensure that if a project meets EDGE requirements it also meets SANS requirements. If there are issues with SANS compliance text alerts will appear below the energy section and will also appear in the downloadable pdf (if the user chooses to generate it). Note that EDGE should not be used as a compliance tool for SANS as there are additional requirements mandated by SANS that are not included in EDGE.

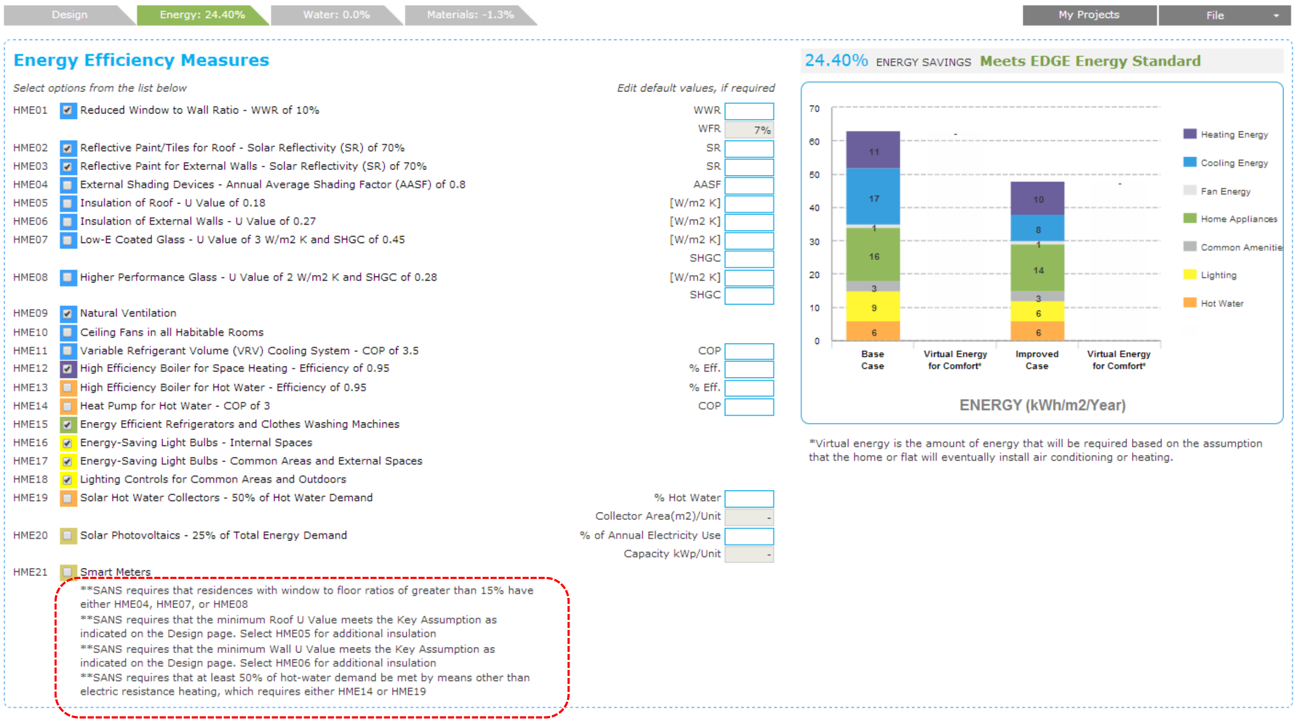

Figure 24. SANS alerts for SA are given at the end of the EE measures when project meets EDGE standard of 20% energy saving but does not meet SANS requirements. This alert is specific to South Africa.

HME01 – Reduced Window to Wall Ratio

South African design teams generally refer to Window to Floor Ratio (WFR). EDGE has therefore introduced WFR into the building Design page and the Window to Wall Ratio section. To change the WFR, the user must modify the WWR. WFR cannot be modified directly in EDGE software.

By changing the WWR, the area of windows changes in the software calculations. This automatically modifies the WFR as follows:

$$WFR = \frac{\text{Total Window Area}}{\text{Total Floor Area}}$$

So, since the floor area remains constant (from the input in the Design page), the window area may be amended by changing the WWR.

WWR and WFR are not directly proportional, although when WWR increases the WFR also increases. However, a conversion factor is not possible since the dependent variables are not the same for WWR and WFR.

HME 05-06- Insulation of Roof and External Walls

Since the South African (SANS) baseline U-Value is low, addition of insulation above and beyond the SANS requirements will not provide a financially viable energy savings option.

HME14 – Heat Pump for Hot Water Generation

When Heat Pumps for hot water are selected as an Energy Efficient measure for South Africa, the system must deliver at least 50% of SANS energy requirements. Therefore, only savings for the remainder of the system will be counted toward EDGE energy efficiency achievements.

APPENDIX

China

Green Building Evaluation Label (GBL), also known as the "3-Star" System

EDGE Version 2.1 includes the ability to demonstrate compliance with certain categories of China's Green Building Evaluation Label (GBL), also known as the "3-Star" System. China GBL is a green building certification program administered by the Ministry of Housing and Urban-Rural Development of the People's Republic of China (MOHURD). GBL evaluates projects based on eight categories: land, energy, water, resource/material efficiency, indoor environmental quality, construction management, operational management and a bonus category for innovation.

The EDGE software can be used to demonstrate compliance in four of the eight GBL categories for the GBL points listed in the table in this section. Note that not all GBL categories are included in EDGE. The EDGE software includes nearly 30 cities in China. The EDGE baseline for projects located in China follows the GBL system instead of the ASHRAE baseline. EDGE also provides GBL-specific calculators for China projects within the EDGE user interface.

Users can create a project in EDGE with a location in China, select the measures included in their project, and use the GBL calculators to generate inputs for the EDGE App. Users can then generate a GBL report in the EDGE App by going to File > Download GBL Report.

Some features unique to the EDGE user interface for China are:

1. The "Building Data" section on the Design tab includes a field for the "Building Shape Coefficient."

   $$Building\ Shape\ Coefficient(C) = \frac{Building\ Exterior\ Area}{Built\ Volume}$$

   The smaller the Building Shape Coefficient, the less the heat loss via the building envelope and the less the energy consumption.
2. The "Building Systems" section on the Design tab includes dropdown menus to select system types for AC and heating.
   - The AC system defaults to a DX Split System
   - The space heating system has four choices
      i. Fuel Gas Boiler
      ii. Layered Combustion Boiler
      iii. Spreader Chain Grate Boiler
      iv. Fluidized Bed Combustion Boiler
3. There are GBL calculators built into the measures. For example, if "HME16: Energy-saving Light Bulbs" measure is selected in the Homes tool, a GBL- Lighting Power Density calculator becomes available. There are also additional GBL calculators available at the bottom of the Energy tab. These are:
   - GBL – Lighting Control, and
   - GBL – Openable Window/Façade Ratio

GBL Category	Measure	Total Points Available through EDGE
ENERGY		**68**

5.1.4 & 5.2.10	Lighting Power Density	8
5.2.1	Window to Wall Ratio	6
5.2.2	Openable Window/Façade Ratio	6
5.2.3	Design Thermal Performance Improvements	10
5.2.4	Equipment Efficiency Improvements	6
5.2.6	HVAC System Energy Saving	10
5.2.9	Lighting Control	5
5.2.13	Energy Recovery from Exhaust Air	3
5.2.15	Waste Heat Recovery	4
5.2.16	Renewable Energy	10
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8.2.10	Natural Ventilation	13
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6.2.6	Water Fixtures	10
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EXEMPLARY PERFORMANCE AND INNOVATION		**5**
11.2.1	Design Thermal Performance Improvements	2
11.2.2	Equipment Efficiency Improvements	1
11.2.4	Water Fixtures	1
11.2.11	Carbon Emission Calculation	1

APPENDIX 2. LIGHTING ASSUMPTIONS IN EDGE

The tables in this Appendix list the assumptions made for Lighting Power Density in the EDGE building models.

Table 53: Indoor lighting power density [LPD] assumptions for the base case and improved case for Homes

Building Type	*Indoor Space Type*	*Base Case [LPD: W/m²]*	*Improved Case [LPD: W/m²]*
HOMES	Bedroom	9.5	6.5
	Kitchen	14.3	9.7
	Living and Dining	4.8	3.2
	Toilet	66.7	11.1
	Utility, Balcony, service shaft	33.3	5.6
	Corridors & Common areas	5.4	4.0

Table 54: Outdoor lighting power density [LPD] assumptions for the base case and improved case for Homes

Building Type	*External Space Type*	*Base Case [LPD: W/m²]*	*Improved Case [LPD: W/m²]*
HOMES	Site Grounds	3.2	2.0

Table 55: Indoor lighting power density [LPD] assumptions for the base case and improved case for Hospitality

Building Type	*Indoor Space Type*	*Base Case [LPD: W/m²]*	*Improved Case [LPD: W/m²]*
HOSPITALITY	Administrative Office	11.8	7.5
	Back of House	10	6.5
	Bars	15.1	5.9
	Basement Car Parking	1.8	1.8
	Breakfast only area	14.0	8.7
	Conference /Banquet	14.0	14.0
	Corridors	10.8	10.8
	Guest rooms	11.8	2.9
	Guest Room Toilets	9.7	2.9
	Health spa	9.7	6.0
	Kitchen	12.9	8.0

	Laundry	6.5	4.0
	Linen and storage	6.5	4.0
	Lobby	11.8	5.9
	Lockers	6.5	5.9
	Reception	12.9	5.9
	Restaurant and Cafeteria	14.0	5.9
	Cafe	12.9	5.0

Table 56: Outdoor lighting power density [LPD] assumptions for the base case and improved case for Hospitality

Building Type	*External Space Type*	*Base Case [LPD: W/m²]*	*Improved Case [LPD: W/m²]*
HOSPITALITY	Site Grounds	1.5	0.8

Table 57: Indoor lighting power density [LPD] assumptions for the base case and improved case for Retail – Department Store

Building Type	*Indoor Space Type*	*Base Case [LPD: W/m²]*	*Improved Case [LPD: W/m²]*
RETAIL – DEPARTMENT STORE	Bathrooms	9.7	6.6
	Car Parking	1.8	1.1
	Cold Storage Area	18.3	16.5
	Corridors and Lobby	5.4	2.2
	Dry Storage	8.6	4.4
	Electronics Area	18.3	16.5
	Food Court	18.6	16.5
	Food Sales	18.6	16.5
	Frozen Storage	18.3	16.5
	General Sales Area	18.3	16.5
	Mechanical & Electrical Room	16.1	11.0
	Offices	10.8	6.6
	Supermarket	18.3	16.5

Table 58: Indoor lighting power density [LPD] assumptions for the base case and improved case for Retail – Shopping Mall

Building Type	*Indoor Space Type*	*Base Case [LPD: W/m²]*	*Improved Case [LPD: W/m²]*

RETAIL - SHOPPING MALL	Anchor Store Area (Supermarket)	18.3	6.6
	Anchor Store Area (Other)	18.3	6.6
	Atrium	5.4	4.4
	Bathrooms	9.7	2.2
	Car Parking	1.8	1.1
	Dry Storage	8.6	4.4
	Food Court	14.0	4.4
	In-line Store Area	18.3	6.6
	Leisure & Entertainment	11.8	6.6
	Mall Area (Communal Corridors)	5.4	4.4
	Mechanical & Electrical Room	16.1	11.0
	Offices	10.8	6.6

Table 59: Indoor lighting power density [LPD] assumptions for the base case and improved case for Retail – Supermarket

Building Type	*Indoor Space Type*	*Base Case [LPD: W/m²]*	*Improved Case [LPD: W/m²]*
RETAIL - SUPERMARKET	Bakery	18.3	16.5
	Bathrooms	9.7	6.6
	Car Parking	1.8	1.1
	Cold Storage Area	18.3	16.5
	Dry Storage	8.6	5.5
	Food Court	14.0	8.8
	Frozen Section	18.3	16.5
	Frozen Storage	18.3	16.5
	General Sales Area	18.3	16.5
	Mechanical & Electrical Room	16.1	11.0
	Offices	10.8	6.6
	Refrigerated Area	18.3	16.5

Table 60: Indoor lighting power density [LPD] assumptions for the base case and improved case for Retail – Small Food Retail

Building Type	*Indoor Space Type*	*Base Case [LPD: W/m²]*	*Improved Case [LPD: W/m²]*

RETAIL – SMALL FOOD RETAIL	Bathrooms	23.7	2.2
	Car Parking	1.8	1.1
	Cold Storage Area	18.3	16.5
	Dry Storage	8.6	4.4
	Food Court	14.0	8.8
	Frozen Section	18.3	16.5
	General Sales Area	7.5	6.6
	Mechanical & Electrical Room	16.1	11.0
	Refrigerated Area	18.3	16.5
	Supermarket	18.3	6.6

Table 61: Indoor lighting power density [LPD] assumptions for the base case and improved case for Retail – Non-Food Big Box Retail

Building Type	*Indoor Space Type*	*Base Case [LPD: W/m²]*	*Improved Case [LPD: W/m²]*
RETAIL – NON-FOOD BIG BOX RETAIL	Car Parking	1.8	1.1
	Corridors and Lobby	5.4	4.4
	Dry Storage	8.6	6.6
	Food Court	14.0	11.0
	General Sales Area	18.3	16.5
	Mechanical & Electrical Room	16.1	11.0
	Offices	10.8	6.6
	Supermarket	18.3	6.6

Table 62: Indoor lighting power density [LPD] assumptions for the base case and improved case for Retail – Light Industry

Building Type	*Indoor Space Type*	*Base Case [LPD: W/m²]*	*Improved Case [LPD: W/m²]*
RETAIL – LIGHT INDUSTRY	Car parking	5.4	3.8
	Cold Storage Area	8.6	7.5
	Food Court	11.8	7.5
	Inventory Area	8.6	7.5
	Mechanical & Electrical Room	8.3	5.0

	Office Space	10.8	7.5
	Production Area	15.0	12.5
	Receiving Area	10.8	7.5
	Shipping Area	10.8	7.5

Table 63: Indoor lighting power density [LPD] assumptions for the base case and improved case for Retail – Warehouses

Building Type	*Indoor Space Type*	*Base Case [LPD: W/m²]*	*Improved Case [LPD: W/m²]*
RETAIL – WAREHOUSES	Bulk Storage	9.7	6.6
	Car parking	1.8	1.1
	Controlled Storage	15.1	11.0
	Dispatcher	18.3	16.5
	Food Court	14.0	11.0
	Inventory Control	11.8	8.8
	Mechanical & Electrical Room	18.3	16.5
	Office Spaces	10.8	6.6
	Package Assembly	18.3	16.5
	Package Disassembly	18.3	16.5
	Rack Storage	15.1	11.0
	Receiving and Shipping	18.3	16.5

Table 64: Outdoor lighting power density [LPD] assumptions for the base case and improved case for Retail buildings

Building Type	*External Space Type*	*Base Case [LPD: W/m²]*	*Improved Case [LPD: W/m²]*
RETAIL	Site Grounds	1.5	1.0

Table 65: Indoor lighting power density [LPD] assumptions for the base case and improved case for Offices

Building Type	*Indoor Space Type*	*Base Case [LPD: W/m²]*	*Improved Case [LPD: W/m²]*
OFFICES	Conference Rooms	14.0	5.4
	Corridors	5.4	1.8
	Food Court	9.7	2.3
	Indoor Car Parking	2.2	1.8

	Lobby	14.0	3.5
	M&E Rooms and Storage	16.1	4.7
	Open Plan/ Cellular Office	11.8	5.4
	Toilets	9.7	4.7

Table 66: Outdoor lighting power density [LPD] assumptions for the base case and improved case for Offices

Building Type	*External Space Type*	*Base Case [LPD: W/m²]*	*Improved Case [LPD: W/m²]*
OFFICES	Site Grounds	1.2	0.8

Table 67: Indoor lighting power density [LPD] assumptions for the base case and improved case for Hospitals – Nursing Home

Building Type	*Indoor Space Type*	*Base Case [LPD: W/m²]*	*Improved Case [LPD: W/m²]*
HOSPITALS – NURSING HOME	Consultation Rooms	16.1	6.7
	Corridors	10.8	2.2
	Dining	14.0	11.8
	Kitchen and Food Preparation	12.9	11.8
	Laundry	1.8	1.6
	Mechanical & Electrical Rooms	16.1	6.7
	Offices	11.8	6.7
	Patient Areas - General	7.5	3.4
	Patient Areas – Specialty Wards	7.5	3.4
	Waiting Areas	11.8	6.7

Table 68: Indoor lighting power density [LPD] assumptions for the base case and improved case for Hospitals – Private Hospital

Building Type	*Indoor Space Type*	*Base Case [LPD: W/m²]*	*Improved Case [LPD: W/m²]*
HOSPITALS – PRIVATE HOSPITAL	Bathrooms and Storage	9.7	2.2
	Central Sterile Supply Department	15.1	2.2
	Consultation Rooms	16.1	6.7
	Corridors	10.8	2.2
	Diagnostic Services	15.1	6.7
	Indoor Car Parking	1.8	1.6

	Intensive Care Units (ICUs)	16.1	6.7
	Kitchen and Food Preparation	12.9	11.8
	Laundry	6.5	2.2
	Mechanical & Electrical Rooms	16.1	6.7
	Offices	11.8	6.7
	Operating Rooms	23.7	11.8
	Patient Areas - General	7.5	3.4
	Patient Areas – Specialty Wards	7.5	3.4
	Pre- & Post-Operating Rooms	16.1	6.7
	Therapy Rooms	16.1	6.7
	Waiting Areas	16.1	6.7

Table 69: Indoor lighting power density [LPD] assumptions for the base case and improved case for Hospitals – Public Hospital

Building Type	*Indoor Space Type*	*Base Case [LPD: W/m²]*	*Improved Case [LPD: W/m²]*
HOSPITALS – PUBLIC HOSPITAL	Bathrooms and Storage	9.7	2.2
	Central Sterile Supply Department	15.1	2.2
	Consultation Rooms	16.1	6.7
	Corridors	10.8	2.2
	Diagnostic Services	15.1	6.7
	Indoor Car Parking	1.8	1.6
	Intensive Care Units (ICUs)	16.1	6.7
	Kitchen and Food Preparation	12.9	11.8
	Laundry	6.5	2.2
	Mechanical & Electrical Rooms	16.1	6.7
	Offices	11.8	6.7
	Operating Rooms	23.7	11.8
	Patient Areas - General	7.5	3.4
	Patient Areas – Specialty Wards	7.5	3.4
	Pre- & Post-Operating Rooms	16.1	6.7
	Therapy Rooms	16.1	6.7

	Waiting Areas	16.1	6.7

Table 70: Indoor lighting power density [LPD] assumptions for the base case and improved case for Hospitals – Multi-Specialty Hospital

Building Type	*Indoor Space Type*	*Base Case [LPD: W/m²]*	*Improved Case [LPD: W/m²]*
HOSPITALS – MULTI-SPECIALTY HOSPITAL	Bathrooms and Storage	9.7	2.2
	Central Sterile Supply Department	15.1	2.2
	Consultation Rooms	16.1	6.7
	Corridors	10.8	2.2
	Diagnostic Services	15.1	6.7
	Indoor Car Parking	1.8	1.6
	Intensive Care Units (ICUs)	16.1	6.7
	Kitchen and Food Preparation	12.9	11.8
	Laundry	6.5	2.2
	Mechanical & Electrical Rooms	16.1	6.7
	Offices	11.8	6.7
	Operating Rooms	23.7	11.8
	Patient Areas - General	7.5	3.4
	Pre- & Post-Operating Rooms	16.1	6.7
	Therapy Rooms	16.1	6.7
	Waiting Areas	16.1	6.7

Table 71: Indoor lighting power density [LPD] assumptions for the base case and improved case for Hospitals – Clinics (Outpatient)

Building Type	*Indoor Space Type*	*Base Case [LPD: W/m²]*	*Improved Case [LPD: W/m²]*
HOSPITALS – CLINICS (OUTPATIENT)	Bathrooms and Storage	9.7	2.2
	Consultation Rooms	16.1	11.8
	Diagnostic Services	15.1	6.7
	Kitchen and Food Preparation	12.9	11.8
	Laundry	1.8	1.6
	Mechanical & Electrical Rooms	16.1	6.7

	Offices	11.8	6.7
	Waiting Areas	11.8	6.7

Table 72: Indoor lighting power density [LPD] assumptions for the base case and improved case for Hospitals – Diagnostic Center

Building Type	*Indoor Space Type*	*Base Case [LPD: W/m²]*	*Improved Case [LPD: W/m²]*
HOSPITALS – DIAGNOSTIC CENTER	Bathrooms and Storage	9.7	2.2
	Corridors	10.8	2.2
	Diagnostic Services	15.1	6.7
	Indoor Car Parking	1.8	1.6
	Kitchen and Food Preparation	12.9	11.8
	Laundry	6.5	2.2
	Mechanical & Electrical Rooms	16.1	6.7
	Offices	11.8	6.7
	Waiting Areas	8.6	6.7

Table 73: Indoor lighting power density [LPD] assumptions for the base case and improved case for Hospitals – Teaching Hospital

Building Type	*Indoor Space Type*	*Base Case [LPD: W/m²]*	*Improved Case [LPD: W/m²]*
HOSPITALS – TEACHING HOSPITAL	Bathrooms and Storage	9.7	2.2
	Central Sterile Supply Department	15.1	2.2
	Consultation Rooms	16.1	6.7
	Corridors	10.8	2.2
	Diagnostic Services	15.1	6.7
	Education, Auditorium	14.0	6.7
	Indoor Car Parking	1.8	1.6
	Intensive Care Units (ICUs)	16.1	6.7
	Kitchen and Food Preparation	12.9	11.8
	Laundry	6.5	2.2
	Mechanical & Electrical Rooms	16.1	6.7
	Offices	11.8	6.7

	Operating Rooms	23.7	11.8
	Patient Areas - General	7.5	3.4
	Patient Areas – Specialty Wards	7.5	3.4
	Pre- & Post-Operating Rooms	16.1	6.7
	Waiting Areas	16.1	6.7

Table 74: Indoor lighting power density [LPD] assumptions for the base case and improved case for Hospitals – Eye Hospital

Building Type	*Indoor Space Type*	*Base Case [LPD: W/m²]*	*Improved Case [LPD: W/m²]*
HOSPITALS – EYE HOSPITAL	Bathrooms and Storage	9.7	2.2
	Consultation Rooms	16.1	6.7
	Corridors	10.8	2.2
	Diagnostic Services	15.1	6.7
	Indoor Car Parking	1.8	1.6
	Kitchen and Food Preparation	12.9	11.8
	Laundry	6.5	1.6
	Mechanical & Electrical Rooms	15.1	6.7
	Operating Rooms	23.7	6.7
	Opticals	16.1	6.7
	Patient Areas - General	7.5	3.4
	Refraction	16.1	6.7
	Waiting Areas	16.1	6.7

Table 75: Indoor lighting power density [LPD] assumptions for the base case and improved case for Hospitals – Dental Hospital

Building Type	*Indoor Space Type*	*Base Case [LPD: W/m²]*	*Improved Case [LPD: W/m²]*
HOSPITALS – DENTAL HOSPITAL	Bathrooms and Storage	9.7	2.2
	Consultation Rooms	16.1	6.7
	Corridors	10.8	2.2
	Diagnostic Services	15.1	6.7
	Indoor Car Parking	1.8	1.6
	Kitchen and Food Preparation	12.9	11.8

	Laundry	6.5	1.6
	Mechanical & Electrical Rooms	15.1	6.7
	Operating Rooms	23.7	6.7
	Waiting Areas	16.1	6.7

Table 76: Outdoor lighting power density [LPD] assumptions for the base case and improved case for Hospitals

Building Type	*External Space Type*	*Base Case [LPD: W/m²]*	*Improved Case [LPD: W/m²]*
HOSPITALS	Site Grounds	1.5	0.8

Table 77: Indoor lighting power density [LPD] assumptions for the base case and improved case for Education

Building Type	*Indoor Space Type*	*Base Case [LPD: W/m²]*	*Improved Case [LPD: W/m²]*
EDUCATION	Auditoriums	6.8	6.0
	Cafeteria - Pre-school	11.4	9.7
	Cafeteria – *all other types*	11.4	9.7
	Changing Rooms	9.1	7.7
	Classrooms	10.3	8.8
	Computer Rooms	12.9	11.0
	Corridors	6.0	4.0
	Indoor Car Parking	1.8	1.4
	Labs	12.9	11.0
	Library	8.8	7.5
	Meeting Rooms	8.7	7.4
	Offices/Administration Rooms – Pre-school	8.7	7.4
	Offices/Administration Rooms – *all other types*	10.3	8.8
	Other Space Types	9.1	7.7
	Playrooms	10.3	8.8
	Restrooms	9.1	7.7
	Sports Room	4.7	4.0
	Staff Rooms	6.0	5.0

	Workshops	12.9	11.0
	Worship Places	10.3	9.0

Table 78: Outdoor lighting power density [LPD] assumptions for the base case and improved case for Education

Building Type	*External Space Type*	*Base Case [LPD: W/m²]*	*Improved Case [LPD: W/m²]*
EDUCATION	Site Grounds	1.5	1.0

APPENDIX 3. RECORD OF POLICY UPDATES IN THE USER GUIDE

Date	*Location*	*Old Text*	*Update*
11/09/2017	Special Ruling Request (SRR)		Added information on Special Ruling Request (SRR) in the User Guide
03/08/2018	Measure E01 – Reduced Window to Wall Ratio	The following examples should be excluded from the calculations of WWR: a) Walls with windows into unconditioned enclosed spaces	The following examples should be excluded from the calculations of WWR: a) ~~Walls with windows into unconditioned enclosed spaces~~
03/08/2018	Measure W07 – Rainwater Harvesting System	This measure can only be claimed if the rainwater collected is used within the building. A rainwater collection system used for landscaping will not satisfy the requirements of the measure.	~~This measure can only be claimed if the rainwater collected is used within the building. A rainwater collection system used for landscaping will not satisfy the requirements of the measure.~~ Water may be used for landscaping
03/08/2018	Measure W14 – Greywater System	This measure can be claimed if there is a grey water recycling system that reuses waste water from kitchens, laundry and bathrooms for the purpose of flushing toilets within the building.	This measure can be claimed if there is a grey water recycling system that reuses waste water from kitchens, laundry and bathrooms ~~for the purpose of flushing toilets within the building.~~ Water may be used for landscaping
03/08/2018	Measure W15 – Blackwater System	Some jurisdictions may not permit the use of recycled black water in buildings for future flushing; in such cases this measure cannot be claimed.	~~Some jurisdictions may not permit the use of recycled black water in buildings for future flushing; in such cases this measure cannot be claimed.~~ Water may be used for landscaping
06/01/2018	Grouping of residential units under Subprojects		Added information on the 10% rule for grouping residential units for the purpose of EDGE certification
07/24/2018	E03 and E04 - Reflective Paint/Tiles for Walls and Roof	(from Supplement) Replace with Solar Reflectance Index (SRI) wherever it appears in the text for this measure.	~~Replace with Solar Reflectance Index (SRI) wherever it appears in the text for this measure.~~ The measures continue to use Solar Reflectance (albedo) as in older versions of EDGE.

08/30/2018	All	Hotel	Hospitality
08/30/2018	All		Service Apartments have been added under Hospitality (the EDGE typology previously referred to as Hotels)
09/19/2018	Green Measures Guidance: Core and Shell		Added conditions for Core and Shell projects that are not fully rented out at the time of certification.
09/19/2018	Green Measures Guidance		Added exceptions for Social Housing projects
09/19/2018	EDGE Assessment and Certification Definitions	[A Single home is a detached single family home…] with minimum floor area of 50 m².	There is no minimum area requirement.
10/04/2018	Materials		Definitions of solid, cored and honeycomb bricks have been updated in line with ASTM standards. Solid bricks = 0-25% voids Cored bricks = 25%-40% voids Honeycomb Bricks = 40%-60% voids
11/07/2018	E32 – Energy Saving Light Bulbs	This measure can be claimed if the light bulbs … are either compact fluorescent (CFL), LED, or T5 type.	This measure can be claimed if the light bulbs … are either compact fluorescent (CFL), LED, or T5, or other types of light fixtures that achieve 90 lm/W or greater. At least 90% of the lamps must be of the efficient type.
11/07/2018	E07 – Natural Ventilation		Additional requirement: If the rooms are air-conditioned, the air-conditioning system in the rooms must be provided with an auto-shut off control that switches the air-conditioning off while the room is being naturally ventilated.

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